Executive Summary

K-Map: From vision to implementation

Measures to increase Korea's interim 2030 climate target and accelerate the transformation of its economy

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Explanatory notes

- The definition of carbon neutral in Korea is equivalent to climate neutral, as it includes all greenhouse gas emissions as estimated in metric tons of carbon dioxide equivalents (CO_2eq). This covers emissions from carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrochlorofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). All sectors of the economy are considered (power, industry, buildings, transport, agriculture, as well as carbon sinks).
- Government targets refer to the plans of the Korean government, as outlined in the 2050 Carbon Neutrality Scenario (which sets greenhouse gas emissions targets for 2050) and the 2030 National Emissions Reduction Target (the Korean NDC, which sets targets for 2030). The Korean government announced both plans in October 2021 by increasing the ambition of its NDC.
- The K-Map Scenario refers to the research findings of three leading Korean climate and energy think tanks for establishing a more ambitious net-zero roadmap published in February 2022.
- The term renewable energy in this study is based on the OECD definition (see https://data.oecd.org/energy/renewable-energy.htm). It does not include by-product gases from steel or petrochemical processes – a point of divergence from official Korean government statistics (in 2019, by-product gases from industry represented some 35% of total renewable electricity generation in these statistics). Thus, the figures on renewable energy in this study may differ from those of the Korean government.

Abbreviations

- BAU: business-as-usual
- CBAM: Carbon Border Adjustment Mechanism
- CCIA: Climate Change Impact Assessment
- EIA: Environmental Impact Assessments
- EIC: Environmental Improvement Charge
- ESS: energy storage system
- ETS: Emission Trading System
- GHG: greenhouse gas
- GPP: Green Public Procurement
- ICEV: internal combustion engine vehicle
- LEV: low-emission vehicle
- LEZ: low-emission zones
- NDC: Nationally Determined Contribution
- PV: photovoltaic
- RE100: Renewable Energy 100
- REC: Renewable Energy Certificate
- RPS: Renewable Portfolio Standard
- SPF: Seasonal Performance Factor
- ZEB: Zero Energy Building

Units

- Euro (€)
- GW: gigawatt
- GWh: gigawatt-hour
- km: kilometres
- Korean won (₩). 1 euro equals 1 350.00 KRW in this report; 1 trillion KRW is equivalent to 741 million euros
- $MtCO_2$eq: Million tonnes of carbon dioxide equivalent
- TWh: terawatt-hour

Preface

Climate change causes tremendous damage to human lives and property. Large-scale wildfires, heavy rains, and extreme weather events are becoming more frequent worldwide and in South Korea (hereinafter Korea). For instance, in August 2022, three days of heavy rains in Seoul caused 14 deaths, displaced 1,500 people, and caused property damage and losses worth more than 50 million euros.

To tackle the climate crisis, advanced economies such as the European Union and the United States have been strengthening their climate commitments and policies. Despite the adoption of a 2050 net-zero commitment, Korea – the 10th largest economy worldwide, and 9th largest emitter – is falling behind when it comes to the ambition of its interim 2030 reduction target (NDC). The introduction of new climate and trade regimes, like the Carbon Border Adjustment Mechanism (CBAM), could significantly affect Korean industry, which relies heavily on export and is responsible for more than 35% of the GDP. These international developments should incentivize the Korean economy to decarbonize more rapidly, in order to preserve its international competitiveness. Put differently, reducing greenhouse gas (GHG) emissions is a prerequisite for sustainable economic growth and for the prosperity and well-being of the Korean population.

The Korean government aims to abate at least 200 million tons of greenhouse gas emissions by 2030 (compared to 2018 levels). While Korean emissions dropped significantly in 2020 due to the COVID-19 pandemic, they increased again in 2021 by an estimated 3.5%. If Korea continues to rely on fossil fuels and does not fundamentally change its energy economy, we can expect these GHG emissions to increase even further as part of the post-pandemic recovery. In other words, to achieve its 2050 carbon neutrality goals, Korea will need to decouple economic growth from GHG emissions.

To address this challenge, the Korean government should devote additional energy to enhancing its climate ambition. In 2022, three leading Korean think tanks – the Green Energy Strategy Institute, Institute for Green Transformation and Next Group – in cooperation with Agora Energiewende, presented an ambitious decarbonization roadmap for Korea – the K-Map Scenario. Elaborating on that work, this study[1] spotlights concrete policies Korea can adopt to accelerate decarbonization in all socio-economic sectors. It also shows the budgetary commitments needed during the current presidency up to 2027 to fulfil the transition pathway of the K-Map Scenario.

1 Please consult the sectorial reports (in Korean only) for more details on policy instrument proposals and budget plans by sector (power generation, industry, buildings, transport, and agriculture).

Key findings

①	To reach net zero by 2050, the Korean government should increase its 2030 climate target and reduce GHG emissions by at least 40% compared to 2018 levels while relying solely on domestic efforts.
②	Power sector emissions should be reduced by almost 60% up to 2030 through three main strategies: phasing down coal, phasing in renewables, and rolling out battery storage.
③	Industrial emissions should be reduced by more than 20% by 2030 by leveraging new obligations (strengthening ETS) and incentives (introduction of Carbon Contracts for Difference) that will increase the competitiveness of low-carbon technologies.
④	Emissions in the buildings sector must be cut by almost 40% by 2030 through an effective green renovation incentive programme and the decarbonisation of heating in existing and new buildings.
⑤	The transport sector must reduce its emissions by more than 40% by 2030 through a mix of subsidies (for low-carbon vehicles) and stricter environmental regulations (such as the gradual ban of combustion engine sales).
⑥	The agriculture sector should cut its emissions by almost 30% up to 2030 through the adoption of a Climate Neutrality and Energy Transition Act for Agriculture, Fishery, and Rural Communities and the promotion of biogas from livestock manure.
⑦	To accelerate the transformation of the Korean economy to net zero, public spending must be increased to 5.33 trillion Korean won (3.9 billion euros) per year up to 2027. Exposing emitting sectors to higher CO_2 prices will generate additional government revenues that can be allocated to the transformation of those sectors.

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1. Power sector

Electricity generation in Korea has consistently grown over the past decades, driven by the economic development of the country. Today, electricity is generated primarily by coal power plants (which accounted for 43% of the generation mix in 2021). As a consequence, GHG emissions have also increased significantly in the power sector, reaching a record of 270 $MtCO_2eq$ in 2018 (about 40% of total national emissions). Because of COVID-19, emissions dropped to 218 $MtCO_2eq$ in 2020, a 19% reduction compared to 2018, but they increased again to an estimated 222 $MtCO_2eq$ in 2021 (a 1.8% increase compared to 2020).

The Korean government aims to reduce the overall GHG emissions of the country to 150 $MtCO_2eq$ in 2030, a 40% reduction compared to 2018 levels. However, this objective is insufficient to put Korea on track to achieving its 2050 net-zero target. In 2022, the research consortium behind this study proposed an alternative decarbonization plan for Korea: the K-Map Scenario,[2] which foresees greater ambition in the power sector – specifically, a 58% reduction from 2018 levels to 112 $MtCO_2eq$ in 2030. To meet this target, Korea will need to accelerate the development of renewable energy while also moving more rapidly to phase out coal power.

The transition to clean power requires robust government support. However, several existing policies hamper such a transition. For example, many local governments have adopted strict distancing rules for solar PV projects; the national government regulates coal power solely with a view to particulates, rather than GHG emissions; and support for the deployment of energy storage systems (ESS) is insufficient.

The power sector will play a key role in decarbonizing other sectors, through the electrification of end uses (electric vehicles, heat pumps) and through the production of e-fuels. It is therefore crucial to promptly decarbonize this sector. To this end, we propose the following four policy pillars, which should put the sector on track to achieving the goals highlighted in the K-Map Scenario.

1.1. Lift restrictive distancing rules that penalize solar PV deployment

Solar PV is one of the cheapest low-carbon power generation technologies. However, the increasing deployment of solar PV has led to complaints from nearby residents. In response, a total of 128 local governments (as of 2020) have adopted restrictive regulations that require renewable energy plants, especially solar PV, to be built remotely from residential areas (for instance, more than 1 km from roads in Uljin-gun, and more than 300 m from roads and 1 km from residential areas in Buyeo-gun). These distancing restrictions represent a major hurdle for the swift expansion of renewable power generation in Korea.

Eliminating the distancing restrictions in relation to roads – while keeping those in relation to residential areas – could provide 524 TWh of additional solar PV generation potential to Korea. By contrast, only 104 TWh of additional deployment potential would be obtained by eliminating the distancing restrictions in relation to residential areas, while keeping those in relation to roads.[3] We conclude that lifting the

2 GESI, IGT, Next Group and Agora Energiewende (2022): 2050 Climate Neutrality Roadmap for Korea – K-Map Scenario: Implementing an ambitious decarbonization pathway for the benefit of future generations and the Korean economy.

3 This is because most residential areas are adjacent to roads, whereas roads, in many cases, are located far from residential areas.

distancing requirement in relation to roads is crucial for accelerating power sector decarbonization. In addition, existing regulations in relation to residential areas should be revised, such that the maximum distancing requirement does not exceed 100 meters.

These measures would also lower administrative costs for PV developers, thus further accelerating the expansion of solar power in Korea.

1.2. Create a forward market to limit coal power generation

Coal-fired power generation is only regulated with a view to particulate emissions. As no mechanisms exist to price CO_2 emissions, coal-fired power generation has low marginal costs. Furthermore, despite the recent introduction of environmental dispatch rules,[4] the share of coal in the power generation mix has not decreased at the pace required to meet 2030 targets.

A new electricity forward market[5] could help reduce coal-fired power generation by aligning future power demand needs with CO_2 emission trajectories. In this new market segment – which would operate as a single buyer market – the authorities would select bids based on their bid price and CO_2 intensity, thus ensuring alignment between future power generation and the falling CO_2 cap. Only bids selected in this forward market would then be allowed to participate in the short-term market, effectively forcing power generators to reduce their volume of coal-fired power generation.

This strongly regulated market mechanism[6] would facilitate a decline in coal-fired generation and would save up to 15.5 $MtCO_2eq$ annually up to 2027 compared to business-as-usual (BAU) emissions.

1.3. Reform regulations to facilitate the integration of energy storage systems

A successful energy transition in Korea will require a significant expansion of energy storage systems (ESS) to cope with the variability of wind and solar power. Energy storage will have a particularly strong role to play in Korea due to the country's geographic position and the associated lack of grid interconnections to other countries. In the K-Map Scenario, grid-scale ESS capacity is expected to reach 68 GW / 332 GWh by 2030. The Korean government has implemented several support measures over the last ten years to increase the profitability of ESS investment (including increasing the Renewable Energy Certificate weighting[7] for projects that combine renewable generation and ESS systems; providing an incentive to ESS that reduce peak demand through a discount on electricity purchase for storage purposes; and tax credits for ESS investment). Despite these supports, ESS have not yet achieved economic feasibility. As a result, total ESS capacity reached 3 GW / 10 GWh in 2021, but 43% of this capacity is not utility scale. In order

4 This mechanism, which introduced a CO_2 component to short-term marginal pricing, should in principle modify the dispatch order. However, this mechanism is not effective in practice since coal-fired power plants receive 90% of their CO_2 allowances for free in the ETS market.

5 Currently, the electricity market in Korea has only one day-ahead segment.

6 Details on the market mechanism are provided in the Korean version of the report.

7 The government has implemented a Renewable Portfolio Standard (RPS) scheme in 2012 pursuant to the New and Renewable Energy Act. Under the Act, an REC (Renewable Energy Certificate) guarantees the origin of the renewable electricity production (per MWh of electricity generated). In addition, a REC weighting has been introduced that varies depending on the renewable source and its generation capacity: for instance, 1.2 for ground mounted PV below 100kW; 1.0 for ground mounted PV between 100kW and 3MW; 1.5 for roof-top PV less 3MW.

to improve the business case for ESS, ESS must be given the same rights as power generators to bid in the various segments of the electricity market, as is the case in the US.

1.4. Increase annual public spending to transform the power sector

In 2023, the state budget allocates 4.3 trillion won (3.2 billion euros) to the power sector, a decrease of about 0.3 trillion won compared to the previous year. The budget flows into five priority areas: low-carbon transition, nuclear energy, resource supply chain, energy affordability for vulnerable consumers, and energy facility safety. While the budget for nuclear energy and the resource supply chain was increased on a year-over-year basis by 19% and 36%, respectively, the budget for the low-carbon transition was decreased by 25%. In particular, the support for renewable electricity decreased significantly, with 124 billion won (92 million euros) less spending on feed-in tariffs and 154 billion won (114 million euros) less spending on subsidies for renewable energy facilities.

In order to reach the 2030 K-Map goal in the power sector, it is necessary to accelerate renewable energy promotion and the deployment of energy storage systems (ESS) and adopt an earlier coal phase-out. To accelerate renewables development, the government's annual budget should be increased from the current 0.945 trillion won to 1.34 trillion won. Since the government budget cannot be mobilised for power grid reinforcement (as the state budget for grid reinforcement is allocated only to R&D projects), it is crucial to add 0.33 trillion won per year to reinforce the grid infrastructure. In addition, about 0.11 trillion won per year is needed to accelerate the coal phase-out. Last but not least, promoting ESS will require an additional 1.43 trillion won per year.

Table1. Budget proposals to reach the 2030 K-Map goal in the power sector

(Billion Korean won)

	Government Budget	Budget proposals to reach the 2030 K-Map goal						
	2023	2023	2024	2025	2026	2027	Total (2023-2027)	Annual average (2023-2027)
Renewable energy promotion	945	1,340	1,340	1,340	1,340	1,340	6,700	1,340
Power grid reinforcement	0	20	20	540	540	540	1,660	330
Earlier coal power plants phase-out	0	0	0	180	180	180	540	110
ESS promotion	0	1,220	1,790	280	2,020	1,830	7,140	1,430
Total	945	2,580	3,150	2,340	4,080	3,890	16,040	3,208

2. Industry Sector

As of 2019, the industry sector in Korea emitted 257 $MtCO_2eq$, accounting for 37% of the nation's total GHG emissions. Energy-intensive manufacturing industries, such as steel, oil refining, petrochemicals, and cement, are the main emitting segments. In addition, rapid growth in the manufacturing of electronics such as semiconductors and displays has led to rising emissions of fluorinated GHGs. Including indirect emissions from electricity and heat use, the industry sector is responsible for about 56% of total GHG emissions in Korea. The four main industry segments – steel, oil refining & petrochemicals, cement, and semiconductors & displays, which together account for half of the manufacturing value added – account for 82% of industrial emissions.

In October 2021, the government set a 2030 emissions target of 222.6 $MtCO_2eq$ for the industry sector. In the K-Map Scenario, these emissions are reduced by an additional 16 $MtCO_2eq$ by 2030. The difference is attributable to the more rapid transformation of the steel sector foreseen by the K-Map Scenario, including the closure of twelve blast furnaces and two FINEX units at the end of their technical lifespans, and the progressive use of green hydrogen as a heat source.

To achieve the goals of the K-Map Scenario, including its 2050 carbon neutrality target, it is necessary to accelerate the transformation of industrial manufacturing processes. The two main existing policy instruments – the Korean Emission Trading System (ETS) and the Environmental Impact Assessment (EIA) for industry complexes – have contributed to a reduction in GHG emissions, but they need to be complemented by additional incentives to effectively channel private-sector investment into innovative low-carbon manufacturing processes. We recommend the introduction of three new policy instruments to accelerate the transformation of industry in line with the K-Map objectives by 2030.

2.1. Introduce Carbon Contracts for Difference and improve the Emission Trading System

Korea introduced an emission trading system (ETS) in 2015. Since then, the system has been gradually improved (e.g. benchmark-based allocation of the CO_2 certificates, modification of the eligibility requirements for free allocation, revision of the free allocation ratio, etc.). Nonetheless, it has been criticized for providing insufficient decarbonization incentives to companies. Specifically, the level of free allocation has been too generous, diluting the financial incentives to reduce GHG emissions and invest in low-carbon processes, thus violating the polluter pays principle. With the recent introduction of international climate-trade regulations (such as the CBAM in the European Union), some Korean industry segments, such as steel manufacturers, have to pay an additional CO_2 tax when they export to Europe. This, in turn, affects their competitiveness.

The adoption of Carbon Contracts for Difference (CCfD) is a suitable new instrument to support decarbonization efforts in high-emitting industries that are also exposed to a risk of carbon leakage. The CCfD is a contract between the government and industrial players. The government agrees to support low-carbon technologies in key sectors at a fixed carbon price (strike price) over a given period. If the CO_2 market price is lower than the strike price, the company receives the difference from the government. If the market price is higher, the company has to relinquish the additional revenue to the government. The strike price should be set at a level that can cover the production cost increases

involved in transitioning from carbon-intensive to low-carbon manufacturing processes. It is also necessary to ensure that companies benefiting from CCfD cannot receive a free allocation of ETS certificates, to avoid double policy support.[8]

In order to implement CCfDs effectively, the ETS must be improved. The level of maximum free allowances must be adapted in line with the 2030 NDC target over the duration of ETS Phase 4 (2026–2030). This will encourage firms to internalize emission costs and also provide sufficient revenues from the CO_2 auctions that can be allocated to the payment of the CCfD and other policies supporting the industry sector. Put differently, it will generate a virtuous cycle in which revenue from GHG polluters is reinvested to reduce GHG emissions in the sector. The CCfD scheme will accelerate the commerciali zation of low-carbon manufacturing technologies and support the country's industrial competitiveness. For instance, in the steel industry, it is anticipated that a maximum of 12 trillion won (8.9 billion euros) in government spending will be required to support the operational costs of hydrogen-based ironmaking technology (DRI) with the capacity to produce 2.7 million tons of green steel per year starting in 2028 for ten years. If all expiring blast furnaces are replaced by DRI facilities, GHG emissions could be reduced by 4 $MtCO_2eq$ per year (for a total of 40 $MtCO_2eq$ over ten years). In other words, each tonne of CO_2eq abated in the steel sector would cost the government approximately 300 thousand won (222 euros).[9]

2.2. Improve Green Public Procurement

Decarbonization in the industry sector is delayed worldwide not only because of technical constraints but also because low-carbon products (based on alternative fuels and materials) have higher unit costs of production. This makes it challenging for low-carbon products to be price competitive in the near future, which in turn hinders a rapid increase in demand for such products. Korea already has a green purchasing policy that requires public organizations to purchase green products. This policy aims to reduce environmental pollution, resource waste, and GHG emissions, and thus contribute to the sustainable development of the Korean economy. However, no adequate assessments of the policy have been performed so far. It is therefore difficult to know whether this policy has effectively encouraged demand for green products. Despite an increase in government expenditures on green products in recent years, as a share of procurement expenditures, spending levels remain unchanged at 2%.

Accordingly, moving forward, the success of the policy should be measured not in terms of mandatory green purchase amounts but rather in terms of the ratio of green purchases to total public procurement. Similarly, a new indicator of GHG emission reductions should be adopted to assess NDC target fulfilment. No less important is the need to designate steel products as green standard products in public procurement and to strengthen the emissions cap for this product category. This will ensure that all steel products purchased by the public sector are low-carbon.

8 Providing both free emissions allocation and CCfD to a certain firm or industry exacerbates the violation of the polluter pays principle. Moreover, it hinders the internalization of carbon emission costs, which results in inefficient use of the governmental budget.

9 This support would be more efficient than the current subsidies provided to industry decarbonization projects in Korea. Indeed, according to our calculations, the current spending on carbon reduction in some Korean industrial sectors can go as high as2.5 million won per tonne of CO_2eq abated (i.e. 1800 euros per tCO_2eq).

Such measures will encourage the transformation of hot-rolled steel production. Producing steel in a blast furnace emits between 0.4 and 1.08 tCO_2 per ton of steel, while the emission factor is reduced to 0.12 tCO_2 per ton of steel in an electric furnace operated with low-carbon power. If all steel products purchased through public procurement are manufactured using electric furnaces, an estimated 0.87 to 1.26 $MtCO_2eq$ could be saved annually.

2.3. Improve Climate Change Impact Assessment framework

Environment Impact Assessments (EIA) examine the potential impacts of a project and set forth measures to mitigate those impacts. In 2010, GHG emissions were adopted as an EIA indicator. However, current enforcement mechanisms are insufficient to ensure compliance with the emission reduction goals at the national or local level. Furthermore, no mechanism exists to verify actual emissions (compared to estimated emissions). Finally, the measures proposed by developers to reduce carbon emissions are often insufficient.

The Climate Change Impact Assessment (CCIA) framework was introduced in September 2022. It applies to large-scale projects such as urban development, industrial complex construction, road construction, energy facilities, and waste treatment facilities. Although such projects and facilities have long-term consequences for GHG emissions, the current CCIA scheme is not sufficiently stringent, as it provides too much freedom in the way emissions are reported (in particular, it calls for an assessment of the environmental impact only in one specific year, rather than over the entire lifecycle of the project).

Therefore, it is necessary to improve the impact assessment regulation by requiring a precise description of long-term GHG projections, clear plans to reduce emissions in the future, and the monitoring of implementation. More specifically, CO_2 emissions over the lifetime of a project should be estimated on a five-year basis until a targeted date and emissions reduction plans should be developed accordingly. In particular, project developers should indicate which decarbonization technologies will be used in their long-term reduction plans. Such plans will spur innovation and reduce uncertainty for investment in low-carbon technologies.

These reforms will ensure that projects run by the national and regional governments are aligned with the 2030 NDC goal. Moreover, requiring long-term CO_2 reduction plans will create demand for low-carbon technologies, thus accelerating their development.

2.4. Augment revenues to support the industry transformation

The Carbon Cognitive Budgeting System is a scheme that evaluates the climate mitigation effects of state-funded projects and policies in Korea. In 2023, a total of 288 projects are being evaluated under this scheme, collectively worth 12 trillion won (8.9 billion euros). Only 85 of these projects fall under the industry sector, accounting for 2 trillion won (1.5 billion euros). The emission reduction potential of all industrial projects supported by the state budget corresponds to just 0.9 $MtCO_2eq$ in 2023, 1.3 $MtCO_2eq$ in 2024, and 1.9 $MtCO_2eq$ in 2025.

In order to reach the 2030 K-Map goal in the industry sector, the government should increase its budget for (1) promoting the development of low-carbon technologies (from currently 128 billion won in 2023

to 614 billion won annually), (2) supporting low-carbon technology pilot projects, (3) supporting the operation of the CCfD scheme. Revenues from the ETS should be used to support those increases in public spending. By increasing the level of CO_2 allowances auctioned in industry (rather than allocated freely) by 5% per year (down from 10% to 30% at present) during ETS Phase 4 (2026–2030) and by increasing the carbon price from 40 thousand won (30 euros) in 2026 to 100 thousand won (74 euros) in 2030, government revenues would grow from their current level of 500 billion won (370 million won) to 1.3 trillion won (1 billion euros) in 2026 and 2.4 trillion won (1.8 billion won) in 2027. Utilizing these newly acquired funds to support CCfDs and low-carbon technology pilot plants would not only contribute to reducing national GHG emissions in the industry sector but would also enhance the international competitiveness of Korean low-carbon industrial technologies.

Table2. Budget proposals to reach the 2030 K-Map goal in the industry sector

(Billion Korean won)

	Government Budget	Budget proposals to reach the 2030 K-Map goal						
	2023	2023	2024	2025	2026	2027	Total (2023-2027)	Annual average (2023-2027)
Promote the development of low-carbon technologies	128	614	614	614	614	614	3,070	614
Support low-carbon technology pilot projects	-	-	-	-	383	978	1,361	272
Support the operation of the CCfD scheme	-	-	-	-	383	978	1,361	272
Total	128	614	614	614	1,380	2,570	5,792	1,158

3. Buildings Sector

In Korea, the buildings sector (which includes residential and tertiary buildings) accounts for approximately 20% of final energy consumption. Furthermore, buildings consume 46% of total electricity production. Coal and oil end uses in buildings are gradually being replaced by electricity, district heating, and renewable energy. The buildings sector is directly responsible for 7.2% of total GHG emissions in Korea, but this share increases to 24.7% if one includes the indirect emissions of electricity consumption. The direct emissions from the buildings sector were on a decreasing trend from 2018 (52.1 $MtCO_2eq$) to 2020 (47.9 $MtCO_2eq$).

The Korean government plans to reduce emissions in the buildings sector to 35 $MtCO_2eq$ by 2030. The K-Map Scenario, however, targets a slightly more ambitious pathway to 32.3 $MtCO_2eq$ by 2030. In terms of cumulated emissions between 2019 and 2030, this represents about 6.7 $MtCO_2eq$ of additional savings.[10]

The main measures for reducing GHG emissions in the buildings sector are energy efficiency retrofitting and switching to decarbonized heating fuels. Korea has implemented green retrofit measures for old buildings and a Zero Energy Building (ZEB) standard for new buildings. However, due to a lack of incentives, these measures have not yet produced tangible benefits. Furthermore, no concrete policies have been implemented for the decarbonization of heating fuels.

In order to accelerate the decarbonization of the buildings sector in line with the K-Map targets, we propose the following four policy measures.

3.1. Adopt a green retrofit roadmap with a mix of incentives and support schemes

Green retrofitting refers to the renovation of existing buildings, including in particular insulation upgrades, to increase energy efficiency and reduce GHG emissions. Starting in 2013, the green retrofit support scheme has led to the renovation of about 0.4% of the country's total floor area per year (including the renovation of 20–30 public buildings and some 10,000 private properties each year).

Several factors limit the pace of green retrofitting in Korea. First of all, Korea has not implemented measures to monitor the energy performance of buildings and also lacks relevant roadmaps and regulations. In particular, Korea has yet to adopt a mandatory mechanism that provides market actors with information concerning a building's energy efficiency (like the EU's Minimum Energy Performance Standard). This means there is little incentive for a building owner to invest in green retrofitting or reduce energy consumption. While government programmes cover 50–70% of the cost to retrofit old public buildings and public rental housing, few support options exist for privately owned buildings, aside from low-interest loans.[11]

Given the clear need to expand government support to privately owned properties, we recommend the adoption of a long-term national roadmap that features specific green-retrofitting targets and measures. During the initial phase of

10 The government estimates that the buildings sector will still emit about 6.2 $MtCO_2eq$ in 2050, while the K-Map Scenario achieves zero direct CO_2 emissions. Over the entire time frame from 2019 to 2050, cumulative emissions are 911.9 $MtCO_2eq$ in the government scenario, but only 748.3 $MtCO_2eq$ in the K-Map Scenario, which represents a reduction of 163.6 $MtCO_2eq$.

11 By contrast, countries such as Germany, the UK and France cover 25–50% of green retrofit expenditures through subsidies or direct loans.

implementation, direct subsidies could be provided to private projects until the attractiveness of the retrofit scheme gains momentum throughout society. As part of roadmap adoption, energy efficiency certification should be made mandatory for all types of buildings (as in the EU). In addition, a new regulation prohibiting the sale or leasing of energy-inefficient buildings should be considered. New support programmes should be implemented, including a repayment bonus scheme depending on the energy reduction level that is achieved. An energy monitoring system should also be established to track building performance following the retrofit. Such schemes will reduce the risk of post-retrofit rebound effects. Finally, we recommend the introduction of new nationwide support programmes, such as on-site energy audits for individual buildings.

3.2. Strengthen the standards for Zero Energy Buildings and provide substantial incentives

A Zero Energy Building (ZEB) is a highly efficient building that relies on renewable energy to cover residual energy needs. Korea launched ZEB certification in 2017. However, the ZEB standards are less stringent than in other countries, and they do not apply to small buildings (less than 500㎡, which account for 85% of the building stock). In addition, no long-term plan exists after 2030, and ZEB incentives are insufficient to cover additional construction costs.

It is, therefore, necessary to strengthen ZEB standards, expand certification to include small buildings, and increase financial incentives to make ZEB construction more attractive. In this connection, we recommend drafting a long-term roadmap up to 2050 that specifies building types and sizes and strengthens standards in line with international best practices. In particular, the ZEB could be split into three sub-standards – ZEB-ready, NZEB (Nearly Zero Energy Building) and Zero Emission Building.

It would be particularly important to require from 2030 onward that all new buildings (public and private) larger than 500㎡ receive NZEB certification and to require all smaller buildings to receive ZEB-ready certification. Moreover, all new public buildings should meet the Zero Emission Building standard by 2035 and all new private buildings by 2040. In this way, all new buildings in Korea would become 100% energy self-sufficient by 2040. In order to facilitate private investment in net-zero buildings, clear financial incentives should be provided to ZEBs, such as reducing the real-estate acquisition tax and annual property taxes.

3.3. Set a mandatory quota for renewables-based heating

As of 2018, fossil fuels accounted for 84% of total residential heating sources in Korea, with the largest share captured by natural gas (64.8%), followed by oil (17.7%) and coal (1.5%). In addition, 17.6% of residential homes in Korea were supplied with district heating in 2022, and further expansion is underway. While many countries, such as the UK, the US, and Germany, have implemented restrictive policies to decarbonize heating energy, Korea has not yet addressed this issue.

In order to accelerate the decarbonization of the heating sector, it is necessary to introduce a mandatory renewable energy quota in residential heating and develop a plan to harness waste heat (from incinerators or sewage wastewater). In

addition, residential buildings should be exempted from the obligation to connect to the natural gas grid if the building has a renewable energy heating system. By doing so, it will be possible to reduce new gas boiler investment and effectively phase out fossil fuels in the heating sector. Finally, at the national level, the government should adopt a plan to increase the use of waste heat and renewable energy in district heating and support local governments to develop carbon-neutral heating energy plans.

3.4. Promote air-source heat pumps and consider them as renewable energy sources

Heat pumps are the most efficient way to provide energy in buildings. In particular, air-source heat pumps have a coefficient of performance (COP) greater than 3, which is significantly more efficient than gas boilers (0.85 to 0.92). Although the efficiency of air-source heat pumps is slightly lower than that of ground-source heat pumps, they are cheaper to install and can be deployed in areas where ground-source heat pumps are not appropriate.

In order to encourage the deployment of air-source heat pumps, they should be recognized as a renewable energy source – thus qualifying them for subsidies – but only if they meet a specific seasonal performance factor (SPF). In addition, since heat pumps are not cost-competitive with fossil-fuel boilers, subsidies for their deployment should be granted prior to 2030, especially for retrofitting old single-family homes that currently rely on coal- or oil-fired boilers.

3.5. Increase the annual state budget for the transformation of the buildings sector

It is essential to increase the state budget dedicated to the decarbonization of the buildings sector. In 2023, this budget stood at 1.24 trillion won (0.9 billion euros), more than 80% of which was allocated to support the green retrofitting of public buildings and public rental housing. In order to achieve the decarbonization pathway of the K-Map Scenario in the buildings sector, this annual state budget should be increased 2.4 times to reach 2.9 trillion won, or 2.2 billion euros in the 2023–2027 period. The budget should focus on supporting all green retrofit projects (including privately owned buildings) and on subsidizing heat pumps.

More precisely, 1.64 trillion won (1.21 billion euros) is needed annually to support the green retrofit of residential buildings and 0.7 trillion won (5 billion euros) for non-residential buildings. With this support, an annual green retrofit rate of 2% is achievable. This would mean the green retrofitting of 428,000 homes (3.9 million won per building) as well as 24,000 commercial buildings (29 million won per building) per annum.

In addition, subsidy support equal to 0.61 trillion won (0.45 billion euros) is needed to replace coal and oil boilers in old homes with 150,000 heat pumps each year. This subsidy, which should cover the difference between the cost of a heat pump and gas boiler (since the gas boiler is the alternative for coal/oil boiler replacement), would cost an estimated4 million won per household.[12] This would allow the replacement of coal/oil boilers with heat pumps in 1.2 million homes by 2030.

With the proposed policy changes and increased budget, a cumulative reduction in energy

12 A new gas boiler costs about 700k to 800k won, while similar size heat pump costs 5 to 6 million won.

consumption of 165 TWh could be achieved in 2023–2027, corresponding to savings of 36 $MtCO_2eq$ compared to a BAU scenario. Specifically, making green retrofitting and the ZEB standard mandatory would reduce energy consumption by 136 TWh (thus avoiding 17.8 $MtCO_2eq$ in emissions); the introduction of a mandatory renewable heat quota in new buildings would reduce consumption by 13 TWh (thus avoiding 13.5 $MtCO_2eq$ in emissions); and the deployment of heat pumps would reduce consumption by 16 TWh (thus avoiding 5.1 $MtCO_2eq$ in emissions).

Table3. Budget proposals to reach the 2030 K-Map goal in the buildings sector

(Billion Korean won)

	Government Budget	Budget proposals to reach the 2030 K-Map goal						
	2023	2023	2024	2025	2026	2027	Total (2023-2027)	Annual average (2023-2027)
Green retrofit	1,020	2,330	2,330	2,330	2,360	2,360	11,710	2,340
Heat pump promotion	220	610	610	610	610	610	3,050	610
Total	1,240	2,940	2,940	2,940	2,970	2,970	14,760	2,952

4. Transport sector

In 2018, the transport sector emitted 98.1 $MtCO_2eq$ in Korea, 97.1% of which arose from road traffic.[13] The share of fossil fuel-based vehicles on the road is extremely high, especially for freight and logistics. Despite a recent increase in eco-friendly vehicles, internal combustion vehicle sales have grown more rapidly.

According to the NDC announced in 2021, the transport sector must reduce its 2030 emissions by 37.8% (compared to 2018). The K-Map Scenario, on the other hand, proposes an emissions reduction of 40.8%. The more ambitious target foresees a higher share of low-emission vehicles (LEV)[14] (specifically, 6.18 million LEVs, compared to 4.5 million in the government plan). In addition, the government anticipates an increase in total vehicles on the road by 2030, leading to a significantly lower share of LEVs (16.7% in the government scenario versus 25.4% in K-Map).

The transport sector in Korea has continuously generated rising CO_2 emissions, despite the implementation of several climate policies. Three main factors explain this trend: low-emission vehicles have not been sufficiently promoted; there are no effective policies to reduce reliance on internal combustion engines; and rail transport demand has been stagnant.

In order to accelerate the decarbonization of the transport sector in line with the K-Map targets, we propose the following six measures.

13 Those emissions do not take into account international aviation and maritime transport. Indeed, according to the IPCC Guidelines for the preparation of GHG inventories, those emissions (also known as international bunker fuel emissions) should be calculated as part of the national GHG inventories of the Parties, but should be excluded from national totals and reported separately.

14 Under Korean law, electric and hydrogen vehicles are LEVs.

4.1. Increase the number of electric vehicles on the road

Submitted in 2021, Korea's revised NDC enhances the LEV adoption target to 4.5 million vehicles by 2030, up from 3 million. However, this target is smaller than the domestic production target of the Korean automobile industry. Also, the government has been subsidizing hydrogen passenger vehicles, despite the rapid development of electric ones. In 2021, a policy was introduced requiring car dealers to sell a given share of low and zero-emission vehicles; however, this obligation is only short-term and fails to provide long-term clarity to automobile manufacturers.

Alignment with the K-Map Scenario will require the sale of at least 6.2 million LEVs by 2030. For passenger cars, the government should adopt a target for the total number of LEVs, without distinguishing between electric and hydrogen vehicles. The subsidy programme should also be revised to consider total LEV production (including electric and hydrogen vehicles). Accordingly, if the production of hydrogen vehicles slows down, then the unused budget can be redirected to electric vehicles.

These measures would allow 9.6 $MtCO_2eq$ of additional savings in the transport sector in 2030. Shifting some of the subsidy support from hydrogen to electric vehicles would also be more efficient from a climate perspective. For instance, if 50% of the budget allocated to subsidize the purchase of hydrogen cars[15] were shifted to promote electric vehicles, this would achieve an additional annual reduction of 0.33 $MtCO_2eq$.

15 In 2022, the subsidy budget reached 622 billion won (461 million euros) and aimed to promote the purchase of 27,650 hydrogen cars (equivalent to 22.5 million won or 16.7 thousand euros per vehicle).

4.2. Gradually ban the sale of combustion engine vehicles

Reducing GHG emissions in the transport sector requires both the large-scale deployment of LEVs and decreasing reliance on internal combustion engine vehicles (ICEVs). However, according to the government scenario, the ICEV fleet is expected to grow up to 2030. Currently, the government supports the early retirement of Grade 5 old diesel vehicles in an effort to reduce particulate emissions, which also considerably reduces CO_2 emissions. The government plans to extend this programme to Grade 4 diesel vehicles while excluding gasoline vehicles.

To achieve the emissions reduction goal, a step-by-step vehicle retirement plan should be adopted with a clear target for the phase-out of ICEVs. Specifically, the sale of all Grade 4 and Grade 5 vehicles should be banned from 2030 onward. These retirement plans should then be gradually extended to all ICEVs,[16] including gasoline vehicles, starting with the highest-emitting vehicles.

These regulations could reduce the number of ICEVs on the road by 4.38 million in 2030, reducing emissions by 20.8 $MtCO_2eq$ over the 2020–2030 period.

4.3. Penalize combustion engine vehicles through stricter environmental regulations

Low emission zones (LEZs) are designated areas in which the operation of high-emitting vehicles is prohibited. LEZs are increasingly popular and have been adopted in major cities across the globe. In Korea, however, only a few LEZs exist, and they aim to reduce particulates (rather than GHG emissions). We recommend the wide adoption of LEZs in Korea. LEZs that are currently applicable only to old diesel vehicles should gradually include all ICEVs, starting with the most polluting vehicles. In addition, the Environmental Improvement Charge (EIC), which is currently imposed only on old diesel vehicles, should be applied to all ICEVs and should include a CO_2 component so that gasoline vehicles that emit more GHGs than diesel vehicles will also be charged accordingly.

The application of the EIC to all ICEVs would generate additional revenues that could be allocated to GHG reduction measures. In 2020, a total of 331.7 billion won (245 million euros) was levied from Grade 4 and Grade 5 diesel vehicles through the EIC. Enlarging the EIC to include all ICEVs would multiply total revenues by a factor of 4.

4.4. Strengthen GHG emission regulations for cars

The regulation of GHG emissions from motor vehicles began in 2012. Vehicle manufacturers and importers are required to keep the average annual GHG emissions of motor vehicles sold below a certain level. However, the imposition of a penalty for a failure to comply with this obligation has been delayed, and data gathered to monitor compliance have not been disclosed since 2019. Accordingly, the regulation is toothless, and compliance is uncertain.

In this way, the existing regulation should be revised to ensure that penalties are effectively imposed for non-compliance. We recommend increasing the penalty to the level foreseen in the EU (i.e. 95 euros

16 In the category of Grade 4 and 5 ICEVs, there are approximately 3.79 million diesel vehicles (2.47 million of which are equipped with a diesel particulate filter), and approximately 590,000 gasoline vehicles.

per gCO_2/km above the standard). Furthermore, the standards themselves (i.e. average fuel consumption and corresponding CO_2 emission limits) should be set to the level mandated in Europe.

These changes would significantly encourage Korean car manufacturers to supply LEVs.

4.5. Promote a modal shift to rail

Rail transport can make an important contribution to achieving carbon neutrality, as it is already energy efficient, and has a higher electrification share than road transport. Truck transport currently dominates the transport of goods in Korea; shifting this transport demand to rail would significantly reduce GHG emissions. However, Korean rail freight infrastructure is extremely underdeveloped, and freight trains primarily rely on diesel (unlike passenger trains, which are mostly electric).

In order to shift transport from road to rail, tax and regulatory reforms are required to increase the competitiveness of rail freight. Fossil fuel subsidies for heavy-duty trucks –- which amount to 1.5 trillion won annually (about 1 billion euros) – must be reduced. At the same time, subsidies for accelerating the modal shift to rail (which currently stand at 3 billion won per year, and have been stagnant over the last 10 years) must be increased. Lastly, the government should make it mandatory for certain economic sectors to use rail freight.

4.6. Increase the annual state budget for the transformation of transport

In 2023, the budget for decarbonizing the transport sector reached 3.3 trillion won (2.5 billion euros), with subsidies for the promotion of LEVs comprising the largest share (namely, direct subsidies for LEV purchase and the construction of charging/fuelling infrastructure). This budget has consistently increased since 2018. However, actual disbursement has not been high, especially for the promotion of hydrogen vehicles, where funding outflows have been minimal. This is because the target for supporting hydrogen vehicles is too high, and the disbursement process fails to consider that electric vehicles are more attractive as passenger cars.

To achieve the goals set by the K-Map Scenario, an accumulate budget of approximately 16 trillion won (12 billion euros) is required between 2023 and 2027, including 9.7 trillion won in subsidies for the purchase of LEVs; 4.3 trillion won for charging and fuelling infrastructure for LEVs; 1.8 trillion won to support the early scrappage of ICEVs; and 0.12 trillion won to promote the modal shift to rail.

Table 4. Budget proposals to reach the 2030 K-Map goal in the transport sector

(Billion Korean won)

	Government Budget	Budget proposals to reach the 2030 K-Map goal						
	2023	2023	2024	2025	2026	2027	Total (2023-2027)	Annual average (2023-2027)
Subsidies for the purchase of LEVs	2,565	2,440	2,397	2,189	1,739	937	9,702	1,940
Charging and fuelling infrastructure for LEVs	519	519	655	826	1,043	1,317	4,360	872
Support for the early scrappage of ICEVs	275	461	268	268	268	564	1,829	366
Modal shift to rail	4	23	23	24	24	24	118	24
Total	3,363	3,443	3,343	3,307	3,074	2,878	16,009	3,202

5. Agriculture sector

In 2018 the agriculture sector emitted 24.7 $MtCO_2eq$,[17] accounting for 3.4% of total emissions in Korea. These emissions can be broadly categorized into livestock, cultivation and energy consumption. In recent years, emissions from livestock have increased, but this has been offset by a reduction in emissions from land use. Direct and indirect emissions from energy consumption have also been on the rise.[18]

Against the backdrop of Korea's 2050 net zero target, annual GHG emissions in the agriculture sector must be reduced by 6.7 $MtCO_2eq$ (government NDC) or alternatively by 7.8 $MtCO_2eq$ (K-Map) up to 2030 compared to 2018 levels. Even though this reduction target is small in absolute terms compared to other sectors, it is high in relative terms, representing more than half of emission reductions compared to 2018 (a reduction of 60% in the K-Map Scenario and of 70% in the government plan).[19]

The Korean government has implemented various policies to reduce GHG emissions in the agriculture sector. However, they have failed to yield significant results. First of all, Korean legal and institutional frameworks still require further development in this regard. Second, policies to promote renewables in rural areas – including strategies to garner local support – have not yet been developed; this is a crucial aspect, given the ageing population in rural areas and rural economic decline. Lastly, statistical data essential for establishing decarbonization strategies in the agriculture sector are still lacking.

In order to accelerate the transformation of the agriculture sector in line with the K-Map goals, we propose the following policy priorities.

5.1. Adopt a Climate Neutrality and Energy Transition Act for the agriculture sector

In contrast to other sectors, net-zero policies in the agriculture sector are based on a single article of the Carbon Neutrality Act. The comprehensive transformation of the sector thus lacks a sound legal basis. A new law must be enacted to promote climate neutrality in the sector while also preserving the public benefits intrinsic to the agricultural and fishing industries. Multiple goals must be pursued simultaneously: namely, improving living standards for farmers, fishermen, and rural communities; achieving climate neutrality in the agricultural and fishing industries; and ensuring a just transition for those impacted.

We recommend the adoption of a Climate Neutrality and Energy Transition Act for Agriculture, Fishery, and Rural Communities that includes the following elements: the promotion of self-sufficient energy systems in rural communities; the abolishment of fossil fuel subsidies; the introduction of direct payments for climate neutral farming practices; the improvement of livestock productivity; the management of agricultural carbon sinks; and the promotion of a dietary shift.

The passage of legislation that calls for climate neutrality in the agriculture sector will furnish the necessary legal basis for enacting additional policies

17 This amount does not take into account emissions from energy consumption in the agriculture sector.

18 As of 2020, the agricultural sector emits 25.5 $MtCO_2eq$ (0.8 $MtCO_2eq$ more than in 2018). Although GHG emissions dropped by 0.1 $MtCO_2eq$ in livestock and agricultural land-use compared to 2018, they increased by 0.9 $MtCO_2eq$ in energy use.

19 Approximately 44% of national methane emissions come from the agriculture sector. In 2021, the Korean government joined the Global Methane Pledge, vowing to achieve a 30% reduction in methane emissions by 2030 (compared to 2020).

and regulations. This will enable the adoption of short- and long-term plans to respond to the climate crisis and reduce GHG emissions in a systematic and effective manner.

5.2. Promote the use of biogases from livestock manure

Biogases from animal manure can help to reduce GHG emissions by converting waste into energy (heat and electricity) and invigorating circular economies. The K-Map Scenario projects that some 3 $MtCO_2eq$ in emissions can be avoided up to 2030 by utilizing 50% of livestock manure in co-generation facilities (to produce heat and electricity). Currently, about 90% of total livestock manure in Korea (approximately 52 million tonnes) is simply composted; just 1.3% is converted to energy. In this regard, several obstacles must be overcome: biogas co-generation plants are currently too expensive; the sourcing of manure is not easy; converting manure into energy is not economically viable; the demand for biogases is low; and site selection is impaired by resistance from local residents.

Given these diverse challenges, the Korean government will need to implement various measures to promote the conversion of livestock manure into biogases. To this end, the Ministry of Agriculture, Food, and Rural Affairs should collaborate with the Ministry of Environment and the Ministry of Trade, Industry, and Energy to launch a Joint Task Force for Circular Bioenergy. The task force should explore various measures, including the development of an organic waste collection system in rural areas; strategies for garnering the support of rural populations; measures to improve the economics of biogas, such as increasing the REC weighting of biogas; and introducing renewable heat incentives in rural areas. The ultimate goal should be to adopt measures that enable the construction of ten biogas cogeneration plants by 2027.

5.3. Revise the Act on the Maintenance and Promotion of Carbon Sinks

While agricultural production is a significant source of GHG emissions (especially due to rice farming and the use of nitrogen fertilizer and urea), soils and forests are an import carbon sink. Thus, policies should be adopted to discourage emissions from farming, while maximizing the GHG absorption capacity of soils and forests.

The Act on the Maintenance and Promotion of Carbon Sinks is the legal basis for expanding carbon sinks in Korea. However, since its enactment was led by the Korean Forestry Service, land uses other than forestry do not fall under the scope of the law.

In order to minimize GHG emissions from agriculture in line with the K-Map Scenario, carbon absorption through agricultural land must be promoted. To this end, various land uses other than forest areas (such as cropland) must be included in the definition of carbon sinks under Article 1 of the Act mentioned above. Subsequently, the Comprehensive Plan for the Promotion of Secondary Carbon Sinks – an overarching plan for carbon sinks – should be revised accordingly.

5.4. Increase the annual state budget for the transformation of the agricultural sector

The 2023 budget of the Ministry for Food, Agriculture, Forestry, and Fisheries amounts to 17.4 trillion won (13 billion euros), accounting for 2.7% of the total governmental budget of 638.7 trillion won

(473 billion euros). While the overall government budget increased 5.1% between 2022 and 2023, the corresponding increase for the ministry was just 2.8%. The government budget for climate mitigation in agriculture is 0.22 trillion won (155 million euros),[20] which corresponds to only 0.7% of the total budget of the Ministry for Food, Agriculture, Forestry, and Fisheries.

There are currently only nine climate mitigation projects in the 2023 Carbon Cognitive Budgeting System that target the agriculture sector. Altogether, the government is allocating 99.7 billion won (70 million euros) to these projects, which promise to achieve GHG emissions reductions of 0.23 $MtCO_2eq$. This corresponds to just a quarter of the emission reductions needed in 2023[21] to achieve the 2030 NDC target in the agricultural sector. In other words, a gap of 0.7 $MtCO_2eq$ exists in 2023 alone. If this trend continues up to 2030, the gap will increase cumulatively to 5.8 $MtCO_2eq$.

In order to fulfil the K-Map Scenario, the budget allocated to the transformation of the agriculture sector must be increased by 5.19 trillion won (3.8 billion euros) cumulatively over the coming five years up to 2027. We recommend the allocation of this funding as follows: accelerating drainage improvement projects (2.43 trillion won); modernizing livestock facilities (1.45 trillion won); expanding the Agricultural and Rural RE100 Project (575 billion won); achieving the energy transition in agricultural machinery (250 billion won); improving agricultural energy-use efficiency (150 billion won); encouraging ecological silvopasture and grazing (72 billion won); establishing a Joint Task Force for Circular Bioenergy (50 billion won); and developing low-methane rice growing standards by agro-climatic zones (42 billion won).

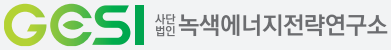
Table 5. Budget proposals to reach the 2030 K-Map goal in the agriculture sector

(Billion Korean won)

	Government Budget	Budget proposals to reach the 2030 K-Map goal						
	2023	2023	2024	2025	2026	2027	Total (2023-2027)	Annual average (2023-2027)
Livestock	109	135	215	304	404	514	1,572	314
Cultivation	373	411	450	494	536	581	2,472	494
Energy consumption	37	48	77	130	283	437	975	195
Total	519	594	742	928	1,223	1,532	5,019	1,003

20 140.9 billion won is allocated from the Ministry for Food, Agriculture, Forestry and Fisheries; the rest from other government agencies (Ministry of Environment, Rural Development Administration, Ministry of Oceans and Fisheries, etc.).

21 This was calculated based on the assumption that emissions are reduced linearly from the actual emissions in 2018 in order to fulfil the 2030 NDC.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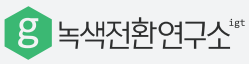
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