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Climate Technology Classification and Statistics on Climate Technology Industry

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Table of Contents

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1 Introduction

1.1. Nationally Determined Contributions and the Paris Agreement

▶ **At the UNFCCC COP 21 (The 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change) in 2015, all Parties negotiated on the agreement on a post-2020 climate regime, as a new regime on climate change differentiated from the Kyoto Protocol, signing on to a Paris Agreement with 196 member countries.**

- Participants of the UNFCCC in 2015 voluntarily submitted a Nationally Determined Contribution (NDC) for the implementation of the Convention on Climate Change reflecting the country's capacity to reduce greenhouse gas emissions (GHGs) and preparing for the ratification of NDC within the country following the signing of the Paris Agreement.

〈Table 1-1〉 **Comparison between Kyoto Protocol and the Paris Agreement**

Contents	Kyoto Protocol (2012-2020)	Paris Agreement (After 2020)
Goal	Reduce quantified emissions (Primary: 5.2%, secondary: 18%)	Compared to the pre-industrial level, hold the global average temperature increases to be well below 2°C and to keep the increase by 1.5°C possible
Scope	Mainly focusing on greenhouse gas reduction	Covering not only greenhouse gas reduction but also adaptation, finance, technology transfer, capacity building, and enhancing transparency
Country with Reduction Obligation	Mainly developed countries	All its member countries
Target Setting Method	Top-down approach	Bottom-up approach
Non-compliance Penalty	Penalty units (1.3 times more emission cuts would be obligated from next term)	No particular penalty
Target Setting Criteria	Not particularly mentioned	Progress principle
Sustainability	Not sustainable due to the pre-set termination point	Sustainable due to no termination intended
Actor	Country-oriented	Encouraging participation of various actors

▶ **The Paris Agreement is based on the premise that not only developed countries but all Parties participated in the Convention on Climate Change must fulfill their reduction obligations.**

- In order to meet the demand and respond to the trend of greenhouse gas reduction in the international community, the Republic of Korea proposed an ambitious reduction plan of 37% reduction by 2030 compared to BAU as its GHGs reduction target while pouring efforts on actual implementation through legislation of the Framework Act on Low Carbon, Green Growth at the national level.

1.2. Climate Technology Development and Transfer

▶ **Climate Technology development and transfer have been discussed at the Conference of the Parties (COP) and emphasized on Article 4 and 7 of the Convention on Climate Change for the last 25 years.**

- In 2001, the 7th Conference of the Parties (COP) adopted the Technology Transfer Framework (TTF) and established the Expert Group on Technology Transfer (EGTT) to analyze the ways to facilitate technology transfer activities. In the 2010 Cancun Agreement, the establishment of the Technology Mechanism, consisting of the Technology Executive Committee (TEC) and the Climate Technology Center and Network (CTCN), has been agreed.

〈Table 1-2〉 **UNFCCC Decisions related to Technology**

Year	Related documents	Descriptions
1992	Agenda 21, Chapter34	Provision of environment-friendly technology transfer, technical cooperation and capacity building on which UNFCCC's technology development and transfer decisions are based
1994	UNFCCC Article 4	Emphasis on the need for technology development and transfer in Article 4 of the UNFCCC Agreement
2001	Marrakesh Accords, Decision4/CP.7	Adopted the Technology Transfer Framework for the implementation of Article 4(5) of the Accords
2007	Bali Action Plan, 1/CP.13	Establishment of AWG-LCA (Ad Hoc Working Group on Long-Term Cooperative Action under the Convention) for long-term cooperation including technology transfer
2010	Cancun Agreement, Decision1/CP.16	Established Technical Mechanism including TEC and CTCN
2015	Paris Agreement, Article 4, 7, 10	Encourage Technology development and transfer

- **The Paris Conference of the Parties (COP) to the Convention on Climate Change in Paris has divided the objectives of establishing the new climate regime into two categories which are mitigation and adaptation.**
  - The Paris Agreement emphasizes and discusses 'technology' as one of the means (technology, finance, and capacity building) of implementation achieving GHGs mitigation and adaptation goals and actively requires practical technology development and transfer activities.
  - The 'Cooperative Action' which specifically deals with the technical aspect of the Paris Agreement, states the obligations for 'developed countries to support developing countries in relation to climate technology development and transfer' and emphasizes its implementation.

- **In the composition of the new climate regime, contents of the Cooperative Action on the development and transfer of climate technologies is important as all parties must fulfill the obligations set forth in the United Nations Framework Convention on Climate Change (UNFCCC) and carry out practical technology development and transfer in accordance with the Financial and Technology Mechanisms on climate change.**
  - However, there is still no strong consensus on the category and level of technology.

2
Climate Technology Classification

2.1. Research Background

- **Due to the lack of consensus on the scope and type of technology in utilizing climate technology mechanisms, international organizations and institutions use all different kinds of classification**
  - Developed countries are emphasizing the technology development in achieving reduction pathways to curb increasing temperatures while developing countries need to develop technologies which will help to improve their climate adaptation capacity.
- **To meet the GHGs reduction target, technology transfer and financial support for developing countries should show substantial results in developed countries.**
  - Use of inconsistent classification and technical scopes can cause confusion among the parties and create difficulties in setting policy directions in the field of technology development.
- **To establish a strategy creating substantive performance, it is necessary to compare active operations of Financial Mechanism and Technology Mechanism by different climate technology categories or to establish clear criteria to compare current situation of home and abroad.**
  - The establishment of a classification at the national level is meaningful as it can be used as criteria for analyzing the current status of R&D investment in the climate technology field and the current status of overseas demand for the private sector's expansion.

2.2. Research Objectives

- **The purpose of this study is to present policy directions for the development and applications of climate technology by categorizing the types of climate technologies that have not yet been classified in terms of scope and level through creating a classification.**
  - The classification provides important policy directions to discuss the priorities in technology development in reducing greenhouse gases at the government level.
  - The classification provides a blueprint for a comprehensive view of the technologies suitable for technology transfer subjecting to developing countries.

2.3. Research Methodology

▶ **Categorize the scope and type of technology through the documentary survey on the current status of domestic and overseas climate technology and implement consultation, review, and evaluation with policy and technology experts on climate change response.**

- **(Documentary survey)** Compares the climate technology classification standards utilized by the IPCC and other international organizations related to climate change to categorize the scope and type of climate technology.

▶ **Obtained a list of climate technology classification and technologies that are used by organizations responsible for international climate change (IPCC, WIPO Green, Climate Tech wiki, Open EI, etc.) and determined the scope and type of climate technology applicable to South Korea.**

- **(Technical consultation)** Expert advisory meeting and survey for technical definition and scope setting/verification and classification of climate technology category.

2.4. Literature Review

2.4.1. Objectives of Climate Technology Development

▶ **The UNFCCC defines climate technology as an essential technology to cope with climate change and to be transferred from developed countries to developing countries.**

- Technology development and transfer is an important means being discussed through negotiations in the composition of a new climate regime, and regarded as one of the implementation means (technical, financial, and capacity building) to achieve goals in GHGs mitigation and adaptation. Its role and importance have been described in Article 10 of the Paris Agreement.
- Article 10 of the Paris Agreement describes the specific details of technology development and transfer in six sections, sharing a long-term vision for technology development and transfer while emphasizing strengthened cooperation, promotion and support.
- Based on the Agreement, conceptual definitions of climate technology can be mainly divided into two, greenhouse gas mitigation and climate change adaptation.

2.4.2. Scope Classification of Overseas Climate Technology

2.4.2.1. Technological Scope of Intergovernmental Panel on Climate Change (IPCC Working Group 3)

▶ **The purpose of the international community's discussions on technology through the Convention on Climate Change and the Paris Agreement is to make an efficient use in GHGs mitigation and adaptation to climate change.**

- In relation to climate change responses, the IPCC (2007) Working Group 3 divided options for GHGs mitigation and adaptation to climate change into two, Mitigation options and Adaptation options, and presented technology and policy as implementation measures.
- The IPCC's Fourth Assessment Report (2007) divided the GHGs mitigation sector into seven sections.

〈Table 2-1〉 Policy Measures for Climate Change Mitigation

Sector		Mitigation Option
1	Energy supply	Improved supply and distribution efficiency; fuel switching from coal to gas; nuclear power; renewable heat and power (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; early applications of carbon dioxide capture and storage (CCS) (e.g. storage of removed CO_2 from natural gas); CCS for gas, biomass and coal-fired electricity generating facilities; advanced nuclear power; advanced renewable energy, including tidal and wave energy, concentrating solar, and solar photovoltaics
2	Transport	More fuel-efficient vehicles; hybrid vehicles; cleaner diesel vehicles; biofuels; modal shifts from road transport to rail and public transport systems; non-motorised transport (cycling, walking); land-use and transport planning; second generation biofuels; higher efficiency aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries
3	Buildings	Efficient lighting and daylighting; more efficient electrical appliances and heating and cooling devices; improved cook stoves, improved insulation; passive and active solar design for heating and cooling; alternative refrigeration fluids, recovery and recycling of fluorinated gases; integrated design of commercial buildings Including technologies, such as intelligent meters that provide feedback and control; solar photovoltaics integrated in buildings
4	Industry	More efficient end-use electrical equipment; heat and power recovery; material recycling and substitution; control of non-CO_2 gas emissions; and a wide array of process-specific technologies; advanced energy efficiency; CCS for cement, ammonia, and iron manufacture; inert electrodes for aluminium manufacture

5	Agriculture	Improved crop and grazing land management to increase soil carbon storage; restoration of cultivated peaty soils and degraded lands; improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions; improved nitrogen fertiliser application techniques to reduce N_2O emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency; improvements of crop yields
6	Forestry/ forests	Afforestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forestry products for bioenergy to replace fossil fuel use; tree species improvement to increase biomass productivity and carbon sequestration; improved remote sensing technologies for analysis of vegetation/soil carbon sequestration potential and mapping land-use change
7	Waste	Landfill CH_4 recovery; waste incineration with energy recovery; composting of organic waste; controlled wastewater treatment; recycling and waste minimisation; biocovers and biofilters to optimise CH_4 oxidation

※ IPCC(2007), IPCC Fourth Assessment Report: Climate Change 2007, Section 5: Synthesis Report, p.60 (https://www.ipcc.ch/publications_and_data/ar4/syr/en/spms4.html)

- Climate change adaptation area is also divided into 7 categories and its policy measures are described.

〈Table 2-2〉 **Policy Measures for Climate Change Adaptation**

Sectors		Adaptation Options
1	Water	Expanded rainwater harvesting; water storage and conservation techniques; water re-use; desalination; water-use and irrigation efficiency
2	Agriculture	Adjustment of planting dates and crop variety; crop relocation; improved land management, e.g., erosion control and soil protection through tree planting
3	Infrastructure/settlement (including coastal zones)	Relocation; seawalls and storm surge barriers; dune reinforcement; land acquisition and creation of marshlands/ wetlands as buffer against sea level rise and flooding; protection of existing natural barriers
4	Human health	Heat-health action plans; emergency medical services; improved climate-sensitive disease surveillance and control; safe water and improved sanitation
5	Tourism	Diversification of tourism attractions and revenues; shifting ski slopes to higher altitudes and glaciers; artificial snow-making
6	Transport	Realignment/relocation; design standards and planning for roads, rail, and other infrastructure to cope with warming and drainage
7	Energy	Strengthening of overhead transmission and distribution infrastructure; underground cabling for utilities; energy efficiency; use of renewable sources; reduced dependence on single sources of energy

※ IPCC(2007), IPCC Fourth Assessment Report: Climate Change 2007, Section 5: Synthesis Report, p.57 (https://www.ipcc.ch/publications_and_data/ar4/syr/en/spms4.html)

2.4.2.2. Technological Scope of United Nations Framework Convention on Climate Change (UNFCCC)

- **Regarding the scope of climate technology, although the UNFCCC does not specify the scope of climate technology, it provides information on climate technology through <TT: Clear>.**
  - The UNFCCC's 〈TT: Clear〉 is an information platform that provides information on the climate technology of each country as a reference, including the information provided by institutions such as IRENA REsource, IRENA inspire, Climate Tech Wiki, WIPO Green, OpenEI, Reegle, The Energy and Resources Institute (TERI)□ and Climate-Smart Planning Platform.

- **In the aspect of the Climate Technology Mechanism, the CTCN member countries provide information on the technology they posess or they research on the website, and they identify the essential climate technology areas neededed for developing countries in connection with TNA.**
  - The CTCN is a UNFCCC climate technology mechanism, which was established based on UNEP and UNIDO, and provides information on GHG mitigation and restoration and development in response to climate change.
  - The Technology Needs Assessment (TNA) provide and evaluate the information on technologies for GHG mitigation and climate change adaptation that reflect the situation of developing countries.

2.4.2.3. IRENA REsource & IRENA inspire

- **IRENA REsource is an online knowledge platform created by the International Renewable Energy Agency (IRENA), which provides information on country-specific metrics such as each country's use and installation of renewable energy for comparison.**
  - The platform provides information on market statistics, potentials, policies, finance, costs, benefits, innovations, education, and other additional topics regarding renewable energy.

- **INSPIRE (International Standards and Patents in Renewable Energy platform) is an online platform created by IRENA that provides information on 400 international standards for renewable energy technology as well as 2 million patents or more.**
  - The INSPIRE platform, in cooperation with IRENA, the European Patent Office (EPO) and the IEC, allows users to search more than 400 internationally recognized databases on renewable energy standards. In the patent section, the platform provides the EPO's PATSTAT, which is the most comprehensive global patent database of carbon reduction technology in the world.

〈Table 2-3〉 IRENA Climate Technology Classification

Division			
1	Bioenergy	1	Biofuels
		2	Solid biofuels
		3	Fuel from waste
2	Enablers	4	Enabling technologies
3	Geothermal energy	5	Geothermal energy
		6	Heat pumps
4	Hydropower	7	Hydropower
5	Ocean energy	8	Ocean energy
6	Solar energy	9	PV - Thermal hybrid
		10	PV
		11	Solar thermal
7	Wind energy	12	Wind power

※ IRENA website : http://resourceirena.irena.org/gateway/#resource-search

2.4.2.4. Climate Tech Wiki

▶ **The Climate Tech Wiki was designed to provide information related to technology transfer to both developed and developing countries. It presents specific information on a wide range of mitigation and adaptation technologies.**

- The Climate Tech Wiki provides detailed information on technologies related to climate change (technology name, sector, and means of use).

〈Table 2-4〉 Climate Tech Wiki Climate Technology Classification

Division			
1	Mitigation	1	Agriculture
		2	Agriculture / Cooking / Electricity
		3	Agriculture / Electricity
		4	Agriculture / Electricity / Waste management
		5	Agriculture / Forestry
		6	Agriculture / Forestry / Industrial efficiency
		7	Agriculture / Transport: Vehicle and fuel technologies
		8	Agriculture / Waste management
		9	Buildings
		10	Buildings / Clean water provision
		11	Buildings / Climate control: heating and cooling
		12	Buildings / Climate control: heating and cooling / Electricity
		13	Buildings / Climate control: heating and cooling / Lighting

		14	Buildings / Demand-side management for electricity
		15	Buildings / Electricity
		16	Buildings / Lighting
		17	Clean water provision
		18	Climate control: heating and cooling
		19	Climate control: heating and cooling / Cooking
		20	Climate control: heating and cooling / Electricity
		21	Climate control: heating and cooling / Electricity / Transport: vehicle and fuel technologies
		22	Climate control: heating and cooling / Electricity / Waste management
		23	CO_2 capture and storage
		24	Cooking
		25	Cooking / Electricity
		26	Demand-side management for electricity
		27	Electricity
		28	Electricity / Industrial efficiency
		29	Electricity / Transport: vehicle and fuel technologies
		30	Forestry
		31	Industrial efficiency
		32	Lighting
		33	Transport: travel behaviour and organization
		34	Transport: travel behaviour and organization / Transport: vehicle and fuel technologies
		35	Transport: vehicle and fuel technologies
		36	Waste management
2	Adaptation	1	Agriculture, livestock, fisheries
		2	Agriculture, livestock, fisheries / Coastal zones / Marine ecosystems / Terrestrial ecosystems / Water resources
		3	Agriculture, livestock, fisheries / Terrestrial ecosystems
		4	Agriculture, livestock, fisheries / Water resources
		5	Coastal zones / Marine ecosystems
		6	Coastal zones / Marine ecosystems / Infrastructure
		7	Coastal zones / Marine ecosystems / Terrestrial ecosystems
		8	Coastal zones / Marine ecosystems / Terrestrial ecosystems / Water resources
		9	Coastal zones / Marine ecosystems / Water resources
		10	Water resources

※ Climate tech Wiki website : http://www.climatetechwiki.org/

2.4.2.5. WIPO Green

▶ **WIPO GREEN was founded by the World Intellectual Property Organization (WIPO) in 2013 providing patent information based on the online database.**

- The Green IPC (International Patent Classification) Codes of WIPO Green provide information on patent classification of GHG mitigation technology for sustainable development complying to IPCC Guidelines.

- However, the Green IPC Codes matching may not be all the same because there could be differences and specificities by each country.

〈Table 2-5〉 **WIPO Climate technology classification**

Division			
1	Alternative energy	1	Biofuels
		2	Integrated Gasification Combined Cycle (IGCC)
		3	Fuel cell
		4	Gasification and pyrolysis of biomass
		5	Utilization of energy extracted from artificial waste
		6	Hydropower
		7	Ocean Thermal Energy Conversion (OTEC)
		8	Wind energy
		9	Solar energy
		10	Geothermal energy
		11	Other methods to generate and utilize heat than chemical combustion
		12	Utilization of free heat
		13	Devices that generate mechanical power from muscle energy
2	Transport	1	General vehicle
		2	Non-railway vehicles
		3	Train cars
		4	Ship propulsion
		5	Aerospace using solar energy
3	Energy conservation	1	Storage means of electric energy
		2	Method for power distribution
		3	Devices for measuring electricity consumption
		4	Storage means of heat energy
		5	Low-power lighting device
		6	Typical insulated building
		7	Regeneration of power energy
4	Waste management	1	Waste treatment
		2	Waste purification
		3	Incineration of waste by combustion
		4	Waste recycling
		5	Pollution control
5	Agro-forestry	1	Forestry
		2	Alternatives to irrigation techniques
		3	Alternatives to pesticides
		4	Soil improvement
6	Management regulatory design	1	Commuting (including IT and high efficiency equipment) / (e.g.) high-occupancy vehicle (HOV), telecommuting
		2	Carbon Emissions (e.g.) Permit for Pollutant Emissions
		3	Building design or structure
7	Nuclear power	1	Nuclear engineering

※ WIPO Green website : https://www3.wipo.int/wipogreen-database/

2.4.2.6. OpenEI

▶ **OpenEI, operated by the US Department of Energy, provides analytic information on renewable energy and energy efficiency in energy sectors.**

- OpenEI provides a) information tools for economic analysis and b) incentive information on renewable energy and energy efficiency by region.

〈Table 2-6〉 **OpenEI Climate technology classification**

Division							
1	Buildings	3	Hydrogen	5	Solar	7	Water
2	Geothermal	4	Smart grid	6	Utility	8	Wind

※ OPEN EI website : http://en.openei.org/wiki/Main_Page

2.4.2.7. Reegle

▶ **Reegle is an internet search engine that addresses renewable energy and energy efficiency.**

- Reegle is a specialized search engine for renewable energy, energy efficiency, and climate change issues which introduces news, blogs, green glossaries, and event information.

〈Table 2-7〉 **Reegle Climate Technology Classification**

Division					
1	Renewable Energy	Energy efficiency (General)	2	Energy Efficiency	Renewable energy (General)
		Agriculture			Biofuels
		Appliances			Biogas
		Buildings			Biomass
		Distribution & metering			Fuel cells
		Electrical			Geothermal
		Energy generation and transmission			Hydro power
		Industry			Hydrogen energy
		Secondary fuel switch (e.g. Electricity with steam)			Marine energy
		Thermal			Solar photovoltaics
		Transportation			Solar thermal electricity
		Utility - Demand side			Solar thermal heat
3	General EE & RE				Wind energy

※ Reegle website : http://www.reegle.info/projectoutputs

2.4.2.8. The Energy and Resources Institute (TERI)

▶ **Since its establishment in 1974 in New Delhi, India, the Energy and Resources Institute (TERI) has conducted research in the fields of energy, environment, and sustainable development.**

- TERI conducts a wide range of research activities ranging from designing regional and national strategies in climate science to conducting research activities that provide solutions to key issues. It also has been involved in various relevant research in different regions of the world including the United States, the United Kingdom, Japan, Malaysia, and UAE.

〈Table 2-8〉 TERI Climate Technology Classification

Division			
1	Agriculture	18	Microbial Biotechnology
2	Biomass Energy	19	Nano technology
3	Climate Change	20	Oil and Gas
4	Coal	21	Plant Biotechnology
5	Distributed Generation & Rural Electrification	22	Power
6	Economy	23	Railways
7	Energy (General)	24	Renewable Energy
8	Environment (General)	25	Roads and Highways
9	Environment - Air	26	Rural Development
10	Environment - Land/Soil	27	Solar Energy
11	Environment - Water	28	Sustainable Development
12	Forestry and Biodiversity	29	Sustainable Habitate / Buildings
13	Fuel Cell and Hydrogen Energy	30	Telecom
14	General Hydro Energy	31	Trade
15	Industry	32	Transport (General)
16	Information and Communication Technology	33	Wind Energy
17	LaBL (Lighting a Billion Lives)		

※ TERI website : http://www.teriin.org/our-work/sector

2.4.2.9. Climate-Smart Planning Platform (CSPP)

▶ **The CSPP was established not only to help policymakers in developing countries to conduct smart planning on climate change issues but also to support them to find and have an access to the tools, data, and knowledge they need to create climate change plans.**

▶ **Currently, the CSPP has been integrated with the Climate Change Knowledge Portal (CCKP) of the World Bank providing comprehensive climate information, data, and means to build a Resilience Planning at global, regional, and national levels by utilizing specific information with different level.**

〈Table 2-9〉 CSPP Climate Technology classification

	Division
1	Biodiversity & Ecosystems
2	Agriculture, Forestry, Fisheries, & Land Management
3	Electricity Generation, Transmission & Distribution
4	Household & Nonresidential Energy Demand
5	Industry & Extractive·Transport
6	Infrastructure & Roads
7	Waste Management
8	Water Resource Management
9	Disaster Risk Management
10	Education, Health & Social

※ https://www.climatesmartplanning.org/dataset/climate-change-knowledge-portal-cckp.html

2.4.2.10. CTCN Classification

- CTCN is one of the climate technology networks, which has been joined by 213 institutions as of 2016, with 74 (34.7%) institutions in the Asia-Pacific region (The largest number of network members in the world), and 72 (33.8%) institutions in Europe.
- It has been shown that each of 213 CTCN affiliates has around 4 specialized research areas on average in climate technology.
  - CTCN presents 15 technology sectors.

〈Table 2-10〉 CTCN Climate Technology Classification

Division			
1	Adaptation	1	Agriculture and forestry
		2	Coastal zones
		3	Early warning and environmental assessment
		4	Human health
		5	Infrastructure and urban planning
		6	Marine and fisheries
		7	Water
2	Mitigation	8	Agriculture
		9	Carbon fixation and abatement
		10	Energy efficiency
		11	Forestry
		12	Industry
		13	Renewable energy
		14	Transport
		15	Waste management

※ https://www.ctc-n.org/technology-sectors

2.4.2.11. TNA Technology Classification

▶ **Technology Needs Assessment (TNA) is a key strategic program, a core commitment of Articles 4 and 5 of the Convention of the UNFCCC, to identify the technology needs of developing countries. It is funded by GEF's Technology Transfer Program while UNEP takes the program enforcement.**

- Based on the analysis report on technology demand submitted by each country, TNA classifies the climate technology field into Action type and Sector. Again, the activity type is divided into adaptation and mitigation, which are classified into 17 sectors as below.

〈Table 2-11〉 **TNA Climate Technology Classification**

Division		
Adaptation · Mitigation	1	Agriculture
	2	Building
	3	Climate change monitoring, forecasting, and early warning
	4	Coastal zones
	5	Coastal zones-monitoring
	6	Energy
	7	Forest and agriculture
	8	Health
	9	Mining and industry
	10	Natural disasters
	11	Planning for climate change and variation
	12	Residential & commercial
	13	Soft structural options
	14	Tourism
	15	Transport
	16	Waste
	17	Water

※ http://www.database.tech-action.org/

2.4.3. Classification Examples of Green Technology in Korea

▶ **Korea established and announced the Strategy for Climate Change Response and the Green Growth Strategy for low carbon green growth.**

- The 「Mid-to Long-Term Master Plan for National R&D in Response to Climate Change」 was established by the Ministry of Education, Science and Technology (MEST) (former name of Ministry of Science and ICT) in 2008 as a basic framework on fields and sectors of technology development.

〈Table 2-12〉 Korea Green Technology Classification

Division		
Climate change	1	Monitoring and modeling for climate change
	2	Climate change assessment and adaptation
Energy source technology	3	Silicon-based solar cells
	4	Non-silicon based solar cells
	5	Bio energy
	6	Light water reactors
	7	Next-generation reactors
	8	Nuclear fusion energy
	9	Hydrogen energy R&D
	10	High-efficiency fuel cell
Efficiency improvement technologies	11	Plant growth-promoting
	12	Integrated gasification combined cycle
	13	Green cars
	14	Intelligent infrastructure for transport and logistics
	15	Green city and urban renaissance
	16	Green buildings
	17	Green Process technology
	18	High efficiency LED / Green IT
	19	IT-combined electric machines
	20	Secondary batteries
End-of-pipe technology	21	CO_2 capture, storage, and processing
	22	Non-CO_2 processing
	23	Assessment of water quality and management
	24	Alternative water resources
	25	Waste recycling
	26	R&D in monitoring and processing of hazardous substances
Virtual reality	27	Virtual reality

2.4.4. Implication of Classification Literature Review

▶ **International institutions related to climate technology use classification in order to provide information with a detailed description of technologies, policy implementation methods, patent status, and economic impacts of technology investments.**

- The classification methods and criteria of those organizations can be categorized largely in 4 types.

① Approach including renewable energy sector only.

- IRENA and OpenEI limits climate technology field to renewable energy sector.

② Approach defining it as an energy technology including nuclear and fossil fuel energy sectors.

- Regarding a whole energy sector as climate technology including renewable energy as Reegle and TERI do.

③ A comprehensive approach including GHG emissions mitigation and adaptation to climate change.

- Institutions like Climate Tech Wiki, WIPO, and CSPP address a broad range of technologies including GHG mitigation and adaptation to climate change.

④ Approach separating projects related to climate change that are requested by developing countries.

- Institutions such as TNA and CTCN may arbitrarily conduct project classification of climate change technologies according to the needs of developing countries under the Technology Mechanism.
- Other organizations such as the World Bank and ADB also present a variety of projects in the climate change sector while none of them uses classification.
- The scopes of 6 key climate change response technologies and 10 major climate technologies that are being used domestically are smaller than the scope used by the international community.
- Thus, domestic standards are not sufficient compared to the international standard to cover the progress of a comprehensive range of climate technology development and to review the information.

▶ **In summary, the classification of climate technology needs a comprehensive approach ranging from climate change adaptation sector to the GHG mitigation sector.**

- In terms of energy technology, not only energy efficiency of renewables but also that of fossil fuels and nuclear energy should be regarded as an issue to be solved.
- In order to increase GHG mitigation effect, R&D and research verification on energy demand management (distributed power management) and technology on energy efficiency (ESS, electric power IT) should be expanded.
- A different approach for the classification that requires the classification to prioritize the needs of technology transfer from developing countries is also considered to have some grounds.

2.5. Establishment on Climate Technology Classification (CTC)

▶ **Composition of Detailed Classification for Climate Change Technology.**

- The following detailed technology fields are organized based on the opinions of technology experts.

〈Table 2-13〉 **Korea Climate Technology Classification**

Field	Category	Technology Scope	Description
Mitigation	(1) Non-renewable energy	1. Nuclear power generation	Technology to design, construct, and operate nuclear power plants with stability, economic efficiency, and environmental friendliness by upgrading nuclear power plants, facilities that produce electricity using fission energy.
		2. Fusion power generation	Technology for producing electric power or hydrogen by recovering the energy of neutrons safely and effectively in the form of heat energy through the control of the fusion reaction occurring in the high-temperature plasma state of deuterium-tritium, and utilizing high-energy neutrons.
		3. Clean power generation and efficiency	High-efficiency clean fossil fuel technology that can achieve CO_2 reduction through fuel diversification by biomass co-firing, high efficiency compared to conventional thermal power generation, fossil fuel purification, CO_2 recirculation, etc.
	(2) Renewable energy	4. Hydro power	Various technologies to convert energy by utilizing the potential energy of water in dams, rivers or watersheds.
		5. Photovoltaic	Technology to convert solar light energy directly into electric energy by using photovoltaic generation system (consisting of solar cell, module, storage battery and power regulator, and AC/DC converter).
		6. Solar thermal	Various technologies concerning conversion, storage and utilization of solar radiation into useful thermal energy.
		7. Geothermal	Technology to produce electricity or heat by using water, underground water and underground heat or temperature difference.
		8. Wind power	Power generation technology that generates electricity by converting the kinetic energy of wind, which is absorbed by the rotor blades, into mechanical energy.
		9. Ocean energy	Relevant technology for practical use of marine clean energy that does not emit carbon dioxide, such as algae, tidal force, wave power, sea water temperature difference, sea water salinity difference, and ocean current.
		10. Bioenergy	Alternative energy source technology that can replace fossil energy by applying thermochemical or biological conversion techniques from animals, plants, or derived resources (biomass) and marine biomass.
		11. Waste	Waste is obtained by using flammable waste of high calorific value generated from daily life and business activities. Waste Energy Technology (WTE) means technology of converting combustible waste with high energy content into waste energy.
	(3) New energy	12. Hydrogen manufacturing	Technology to manufacture hydrogen by converting fossil fuel or decomposing water by thermochemical, photochemical - thermochemical, photochemical, electrochemical, biological, and chemical methods.

		13. Fuel cell	Technology to simultaneously produce electricity and heat with high generation efficiency and low emission by directly converting the chemical energy of fuel (hydrogen, methanol, coal, natural gas, petroleum, biomass gas, landfill gas, etc.) into electric energy through electrochemical reaction.
	(4) Energy storage	14. Power storage	Technology that includes energy storage technology and peripheral device technology that can reduce the greenhouse gas emissions by improving electric power quality and maximizing energy efficiency by storing and using electric energy with high efficiency.
		15. Hydrogen storage	Techniques to safely and efficiently store produced hydrogen in compression, liquefaction, adsorption using media and storage or in the form of hydrogen compounds.
	(5) Transmission and distribution, electric power IT	16. Transmission and distribution system	Technology to develop digital and intelligent power system and heavy electric machine as well as high value added electric power service by introducing information and communication technology and automation system into power technology such as power generation, transmission and distribution, including parts and system technology development, and intelligent power monitoring and control technology.
		17. Electric intelligence device	Products, technologies, systems, and linkage technologies to reduce energy use losses and maximize energy saving effects.
	(6) Energy demand	18. Efficient transport	Technology that contributes to the reduction of greenhouse gas emissions from transport sector by improving the energy efficiency of land, sea and air transportation means that transport passengers and cargo and optimizing transportation and logistics systems.
		19. Industrial efficiency	Infrastructure technology suitable for conversion to the industrial structure that links low-carbon type raw material substitution considering the whole process from raw material collection to post production waste disposal and recycling and integrated high efficiency new processing in order to fundamentally reduce the energy that is injected and distributed in various forms in the industrial sector, which is the processing body of petroleum and resources.
		20. Building efficiency	Technology for Optimizing Energy Efficiency of Core Parts and Existing Buildings in the Expansion of Zero Energy Building, the Key Agenda of the New Building for the National Greenhouse Gas Reduction.
	(7) Greenhouse gas fixation	21. CCUS	Technology that captures CO_2 from mass sources, compresses and transports it to safely store it in land or marine environment, directly use it, or converts it directly into useful materials.
		22. Non-CO_2 reduction	Technology to collect, refine, utilize and decompose processing technologies and to develop alternatives materials and alternative processes that can improve emissions from its source to monitor and database the status of non-CO_2 greenhouse gases and to reduce them.
Adaptation	(8) Agriculture and animal husbandry	23. Improving genetic resources and genetics	Technology that is required to understand the impacts of climate change on crops and livestock production as well as technologies that minimize adverse impacts such as reduced agricultural and livestock productivity by climate change.
		24. Crop cultivation and production	
		25. Livestock disease management	

		26. Processing, storage and distribution	
	(9) Water	27. Water quality and ecology	Technology related to water quality improvement, water resources, water storage and supply, etc. in order to address regional and seasonal water quality degradation and water imbalance, excess and shortage due to climate change.
		28. Water resources securement and supply	
		29. Water treatment	
		30. Water disaster management	
	(10) Climate change forecast and monitoring	31. Climate forecast and modeling	Technology for tracking, diagnosing and predicting past, present and future climate patterns through observation, monitoring and analysis of natural and anthropogenic factors of climate change and numerical modeling of factors that change the global climate system.
		32. Climate information alarm system	
	(11) Marine, fisheries, and coastal	33. Marine ecosystem	Technology including R&D and policy projects required to strengthen science capacity and establish adaptation strategy in response to climate change in marine/fishery/coastal management fields.
		34. Fisheries resources	
		35. Coastal disaster management	
	(12) Health	36. Infectious disease management	Technology that can be used to prevent a wide range of diseases caused by environmental changes due to climate change.
		37. Food safety prevention	
	(13) Forest/land	38. Forest production promotion	Technology to maintain and promote forest health and diversity in the long term by conserving the biodiversity, promoting the absorption and storage of carbon dioxide in the atmosphere and reducing the damage caused by disasters and pests, in a complicated system where carbon is absorbed and stored but the system could be a source of emission due to human impacts such as damages or disasters or maladjustment to climate change.
		39. Forest damage reduction	
		40. Ecology · monitoring · restoration	
Mitigation/ adaptation convergence	(14) Multi-disciplinary convergence	41. Renewable energy hybrid	Technology that includes low-power consumption equipment and energy harvesting technologies, as well as technologies related to power, heat and gas supply·management systems (renewable energy hybrid systems) that combine energy storage systems with two or more energy production systems including renewable energy.
		42. Low-power consumption equipment	
		43. Energy harvesting	
		44. Artificial photosynthesis	
		45. Other climate change related technologies not covered in this classification	

3 Statistics on Climate Technology Industry

3.1. Purpose

▶ **A statistics for publication on the information about Scale (sales) of Korean Climate Technology Industry, R&D funds, Employment (number of employees).**

- As there are many companies whose Climate Technology business is ancillary, it is necessary to make a conclusion after including the detailed information of those companies about its Climate Technology-related performance.
- First, the sales amount means the business scale of Korean Climate Technology Industry. Second, R&D funds mean Korea's investment capacity and commitment. Third, the number of employees is an index for its potential for job creation.

3.2. Research Background

▶ **The UNFCCC has designated the Ministry of Science and ICT of Korea as the National Designated Entity (NDE)('15.12) and GTC is closely supporting Korean NDE.**

▶ **GTC's one of the roles is making statistics on Climate Technology and designated as a statistical agency on Climate Technology based on Article 15 of the Statistics Act of Korea.**

3.3. Data Collection and Methodology

3.3.1. Definition of Climate Technology Industry

▶ **Climate Technology**

- "Climate Technology" is a technology for activities to contribute to GHG mitigation including renewable energy sources such as wind power, solar and hydro power, which means comprehensive technologies such as drought-tolerant crops, early warning systems and the construction of breakwaters to adapt to the adverse effects of climate change. The climate technology category include 'light' technologies such as energy efficiency practices and know-how for the operation of products and appliances (UNFCCC, 2015).

Climate Technology Classification (CTC) : Definition of Categories

① (GHGs mitigation) In the Glossary of Terms of IPCC (2012), the term 'Mitigation' is defined as "An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases."

- The mitigation sectors are divided into energy supply, energy storage and transportation, energy demand and greenhouse gas fixation, and the sectors are further sub-divided into seven categories.

② (Climate change adaptation) In the IPCC Glossary of Terms (2007), 'Adaptation' is expressed as "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities."

- Includes overall technologies to address environmental, social, and economic risks and impacts resulting from climate change in a human and natural system.

③ (Mitigation and Adaptation Convergence) Activities that contribute to the mitigation of greenhouse gas, or to prevent damage caused by climate change, including a combination of both mitigation and adaptation technologies or a convergence of multiple technologies.

- There is no separate classification for those technologies according to the IPCC Glossary of Terms, but with the emergence of the new technology due to technological advancement and the interdisciplinary fusion, new category is added in establishing the climate change classification to cover emerging mitigation and adaptation technology.

Link the climate technology classification (CTC) with the CPC Y code

- CPC (Cooperative Patent Classification) Advanced Patent Classification developed by EPO (European Patent Office) and USPTO (US Patent and Trademark Office).
- This statistic divides the climate technology industry into 10 fields by linking the CTC code and the CPC Y code.

〈Table 3-1〉 Climate Change Related CPC Y code classification

1. Y02B Buildings

Renewable energy integration in the building, energy-efficient lighting technology, energy-efficient HVAC, appliances efficiency improvement technology, energy enhancement technology for elevator, escalator, and moving walkway, ICT technology for energy use reduction, improved technology for power management and consumption on end-user side, building and construction technology for enhancing building thermal efficiency.

2. Y02C Greenhouse gas capture and storage

Carbon dioxide capture and storage, capture by biological degradation, capture by chemical degradation, capture by absorption, capture by adsorption, capture by membrane or divergence, capture by rectification and condensation, carbon dioxide storage of underground or deep sea, Non-CO_2 GHG collection and processing, N_2O, Methane, PFC, HFC, SF_6.

3. Y02E Energy generation, transmission and distribution

Power generation by renewable energy, combustion technology with mitigation potential, power generation by nuclear power, efficient power generation and transmission and distribution technology, non-fossil fuel production technology, non-direct technology contribution to GHG emission reduction, energy conversion or management system to reduce GHG emissions.

4. Y02P Production or processing of goods

Technology related to metal processing, technology related to chemical engineering, technology related to petroleum refining industry, technology related to mineral processing, technology related to agricultural and dairy industries or production to stock, technology related to enrichment industry or stockpile industry, climate change adaptation technology for production process of final industrial or consumer product, climate change adaptation technology for sector-wide adaptation, GHG emission mitigation potential technology.

5. Y02T Transportation

Products and human land transport, products or passenger transport by railway, space or air transport, marine transport, GHG emission reduction technologies.

6. Y02W Wastewater treatment and waste management

Water treatment technology, solid waste management technology, GHG emission mitigation possibility technology.

7. Y04S Smartgrid

Power generation and transmission and distribution support system, Management and operation support system for fixed use on end-user side, support system for specific end users in transport sector, information and communication technology supporting power generation and transmission and distribution, market activities related to smart grid operation.

〈Table 3-2〉 Climate Technology Classification for the 'Statistics on Climate Technology Industry'

Code	Classes	Code	Divisiones	Term Definition
M1	GHG mitigation	M11	(1) Non-renewable energy	Technology field of energy generation · conversion from energy source with less greenhouse gas emission than conventional fossil fuel such as coal and petroleum which is not renewable energy. (Example) nuclear power generation, fusion power generation, clean power generation and efficiency
		M12	(2) Renewable energy	Technology field of energy generation · conversion from renewable resources such as sunlight, water, geothermal, precipitation, or bio-organisms as a fossil fuel alternative energy. (Examples) hydro, photovoltaics, solar thermal, geothermal, wind power, marine energy, bioenergy, waste energy
		M13	(3) New energy	Technology field of energy generation · conversion to obtain alternative energy through conversion of existing fossil fuels or through chemical reactions such as hydrogen and oxygen. (Example) Hydrogen production, fuel cell
		M14	(4) Energy storage	Technology field to store energy generated through power generation · conversion by using devices or media. (Example) Power storage, hydrogen storage
		M15	(5) Transmission and distribution, and energy management	Field to deal with high-efficiency transmission and distribution system as well as energy management system through intelligent power network. (Example) HVDC, distributed power supply system, etc. electricity distribution system, energy management system, etc. electric intelligence device
		M16	(6) Energy demand	Technology field for efficient use or reduction of energy, which is sub-divided according to demand areas (transportation, industry, architecture). (Example) Efficiency of transportation system, next-generation automobile transportation efficiency, improvement of process energy efficiency, alternative efficiency of raw materials such as industrial efficiency, active architecture, building renewal, etc.
		M17	(7) Greenhouse gas fixation	Technological field that directly captures and processes greenhouse gases (CO_2, Non-CO_2) generated during energy production and supply process. (Example) CO_2 reduction and utilization (CCUS), non-CO_2 related capture, transportation, storage, utilization, and conversion technology
A2	Climate change adaptation	A21	(8) Agriculture· animal husbandry	Technology field to identify effects on crops and livestock production by climate change or minimize the adverse effects. (Examples) Genetic resources and genetic improvement, crop cultivation and production, livestock breeding management, agricultural and fisheries processing/storage/distribution/ consumption
		A22	(9) Water	Technology field to solve regional and seasonal water quality degradation and water resources imbalance, excess, and shortage and due to climate change, including water quality improvement, water resources securement, storage, and supply. (Example) Water and aquatic ecosystem, water resources securement and supply, water disaster management
C3	Mitigation and adaptation convergence	C31	(10) Mitigation and adaptation convergence	Hybrid technology with two or more energy production system and energy storage system in combination including renewable energies, power, heat, and gas provision and management system (renewable energy hybrid system), and other technologies including waste resources recycling, low power consumption equipment, and energy harvesting. (Example) New & renewable energy hybrid, low power consumption equipment, energy harvesting, artificial photosynthesis, etc.

3.3.2. Industry Statistics Output Method for Climate Technology

▶ **A sample survey was conducted on the percentage of statistical figures (Amount of sales/R&D investment/Employment scale) subjecting to companies holding patents on climate change to conclude the 'Statistics on Climate Technology Industry'.**

※ A sample survey was conducted to calculate the 'Percentage of Revenue / R&D / Number of Employees by Climate Industry Companies' compare to the total estimated population value in order to utilize the results as the factor proportion.

- The results are evaluated by applying the factor proportion of the survey to the total value by climate technology sector and business size brought from the data of the Statistics Korea, the national statistics office of Korea.

① The data of all domestic climate technology patents and patent holding companies are extracted from the Korean Intellectual Property Office (KIPO).

- They are the data on companies with patents (Application and registration) with CPC Y code (Y02, Y04) related to climate change for last past 14 years (2004~March 2017) as of March 2017.

〈Table 3-3〉 **CPC Y code's number of application/registration in Korea**

no.	Code	Division	Applications Number	Registrations Number
1	Y02B	Climate change mitigation technology related to buildings	10,187	5,289
2	Y02C	Capture, storage, isolation or disposal of greenhouse gas [GHG]	230	91
3	Y02E	Mitigation of greenhouse gas [GHG] emissions, energy production, transmission, or distribution	23,179	9,370
4	Y02P	Production or processing technology	2,958	1,304
5	Y02T	Transportation related technology	6,040	2,505
6	Y02W	Wastewater treatment or waste management technology	4,519	3,205
7	Y04S	Electricity generation, transmission, distribution, management and smart grid	910	325
Total			48,023	22,089

② Companies with experience in climate technologies that are currently in operation are selected for the population to calculate the industry statistics of climate technology.

③ Amount of Sales/R&D investment/Employment scale of climate technology companies were calculated compared with the data from the Statistics Korea.

3.4. Results

3.4.1. Population Status by Climate Technology

▶ **The total number of companies holding 47,880 patents with CPC Y02, Y04 code (application, registration) related to climate change were 8,301 from 2004 to March 2017, while among them, 6,644 companies are currently in business.**

- After linking the detailed code of the climate technology patent (CPC Y patent) with the climate technology classification, totally 6,644 companies were selected as main players in the representative climate technology field.

〈Table 3-4〉 **Population Status by Climate Technology in 2016**

Division	Category	Company size			Others (NPO, Research Institutes, etc)	Total
		Large company	Middle standing company	Small and medium-sized company		
Mitigation	Non-renewable energy	1	1	66	9	77
	Renewable energy	19	85	1,866	101	2,071
	New energy	6	13	100	8	127
	Energy storage	21	63	370	17	471
	Transmission and distribution, and energy management	22	25	320	22	389
	Energy demand	70	183	2,098	79	2,430
	Greenhouse gas fixation	1	2	35	2	40
	Summary	140	372	4,855	238	5,605
Adaptation	Agriculture and animal husbandry	1	7	213	6	227
	Water	10	24	602	10	646
	Summary	11	31	815	16	873
Mitigation and adaptation convergence	Mitigation and adaptation convergence	2	9	150	5	166
	Summary	2	9	150	5	166
Total		153	412	5,820	259	6,644

3.4.2. Climate Technology Industry Statistics

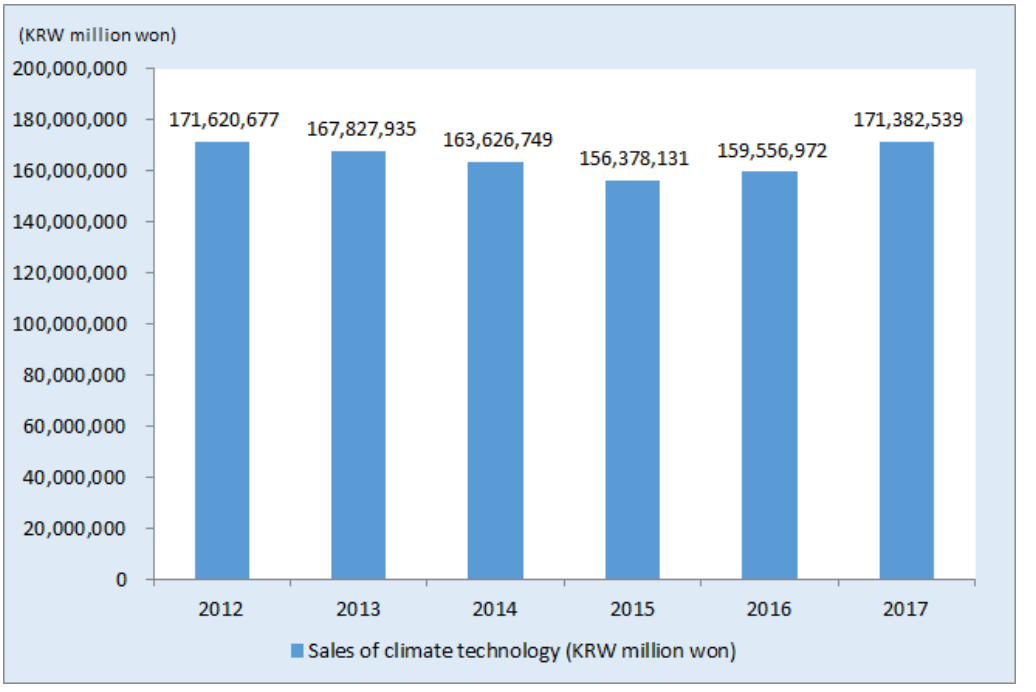
3.4.2.1. Overall Status of Climate Technology Industry

▶ **Amount of Sales in the Climate Technology Industry from 2012 to 2017**

- Over the past six years, the overall sales of the climate technology industry have been declining with an average annual growth rate of -0.03%. From 2012 to 2017, the average amount of sales turned out to be 165,065 billion won.

  * The results of estimating the total sales of the climate technology industry from 2012 to 2017 using the Corporate Register, the statistics office's administrative statistics data.

- As of 2017, the total amount of sales from the climate technology industry were about 171,382 billion won. Although there was a decreasing trend from 2012 to 2015, and recovering in 2016 from the previous year.



(unit: KRW million won)

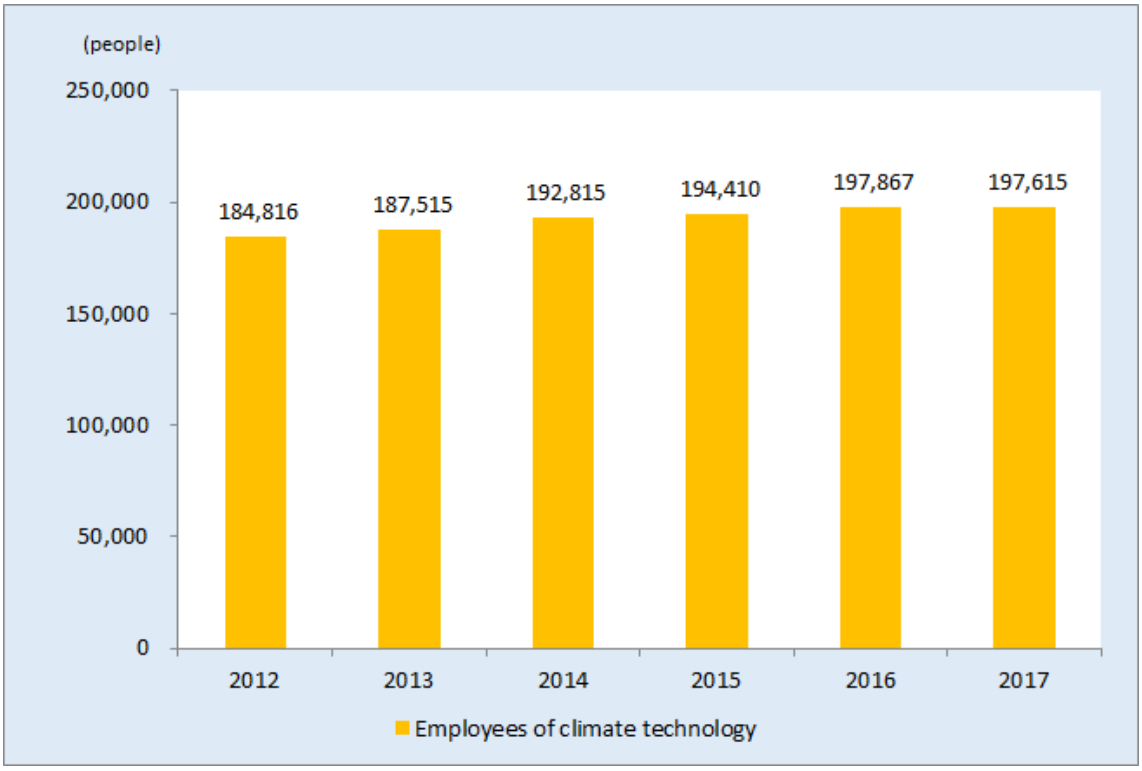
Year	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
Amount of Sales in climate technology	171,620,677	167,827,935	163,626,749	156,378,131	159,556,972	171,382,539	165,065,501	-0.03%

The Number of Employees in the Climate Technology Industry from 2012 to 2017

- Over the past six years, the overall number of employees of the climate technology industry have been increasing with an annual rate of 1.35%. From 2012 to 2017, 192,506 people on average have engaged in climate technology-related work.

  * The results of estimating the number of employees of the climate technology industry from 2012 to 2017 using the Business Register, the statistics office's administrative statistics data.

- As of 2017, the total number of employees in the climate technology industry was approximately 197,615. The number of employees grew to more than 190,000 in 2014, with 192,815 employees.



(unit: people)

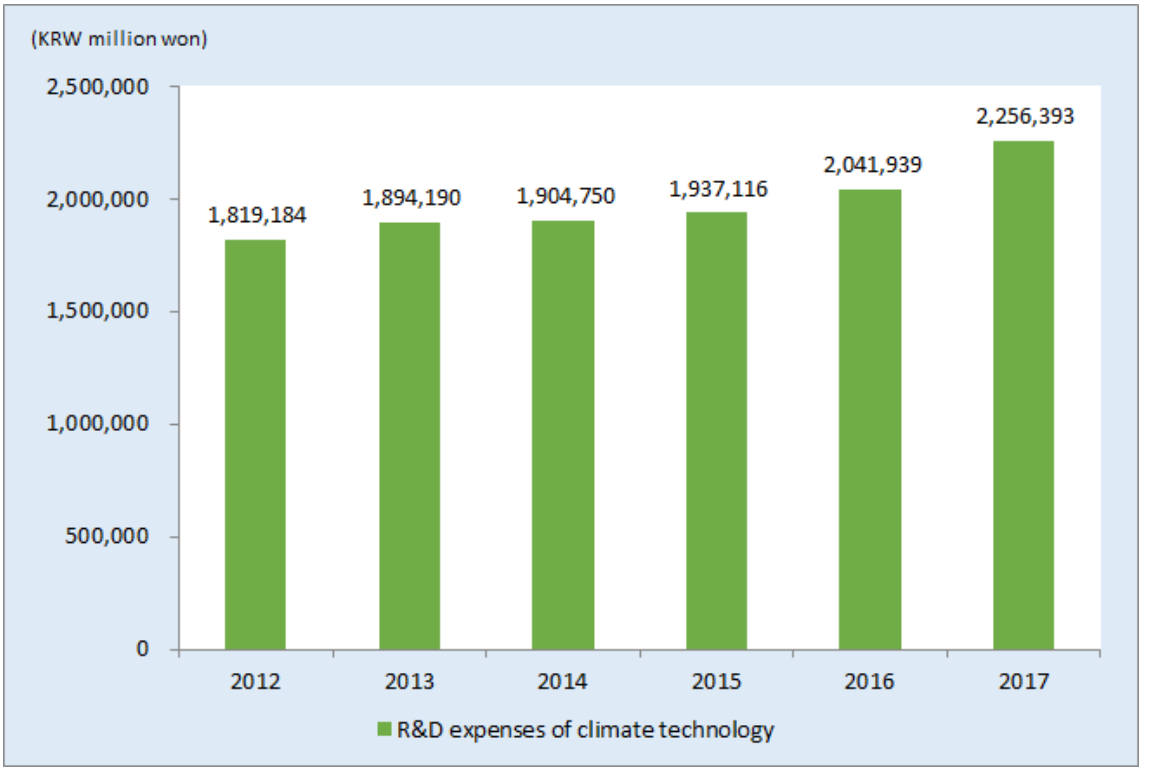
Year	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
Number of Employees of climate technology	184,816	187,515	192,815	194,410	197,867	197,615	192,506	1.35%

Amount of R&D Expenses in the Climate Technology Industry from 2012 to 2017

- Over the past six years, the overall R&D expenses of the climate technology industry have been increasing with an annual average growth rate of 4.40%. From 2012 to 2017, on average, R&D investment worth 1,975 billion won was made.

  * The results of estimating the R&D expenses of the climate technology industry from 2012 to 2017 using the R&D Expenses, data from the statistics office's administrative statistics data.

- As of 2017, the total amount of the R&D expenses in the climate technology industry turned out to be about 2,256 billion won, and it has been steadily rising from 2012 to 2017.



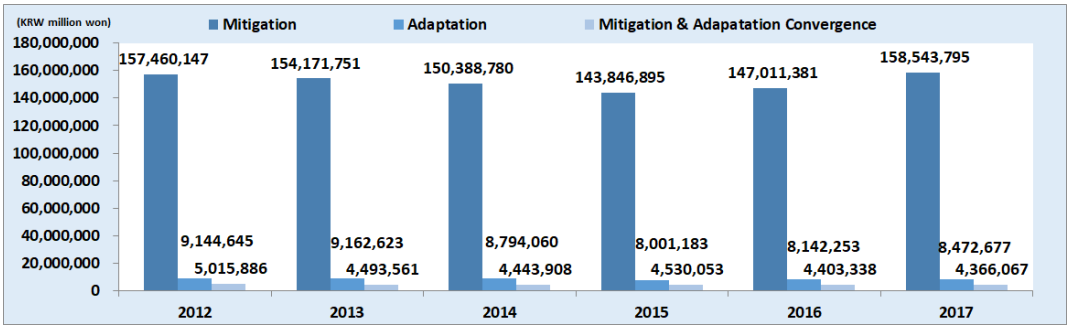
(unit: KRW million won)

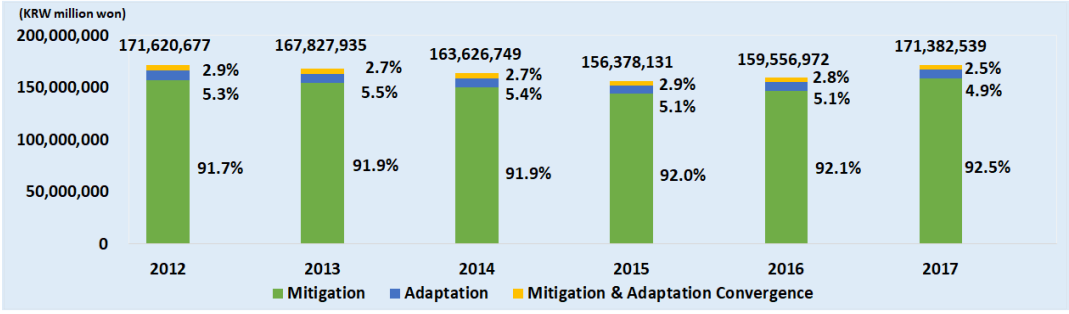
Year	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
R&D expenses of climate technology	1,819,184	1,894,190	1,904,750	1,937,116	2,041,939	2,256,393	1,975,595	4.40%

3.4.2.2. Status by Technology division in the Climate Technology Industry

▶ **Amount of Sales by Tech-division in the Climate Technology Industry from 2012 to 2017**

- More than 90% of sales in the climate technology industry between 2012 and 2017 covered by mitigation.
- Based on 2017, sales amount in the sector of mitigation accounted for 92.5% of the total climate industry. About 158,543 billion won, the highest sales amount among the three categories, was recorded in 2017.
- The average annual growth rate of sales by sector in the climate technology was 0.14% in the sector of mitigation, -1.51% in the adaptation sector and -2.74% in the convergence sector, showing an increasing trend from 2016.
- The sector of mitigation showed an average sales amount of 151,903 billion won from 2012 to 2017. The adaptation sector recorded 8,619 billion won and the convergence sector recorded 4,542 billion won in sales amount.



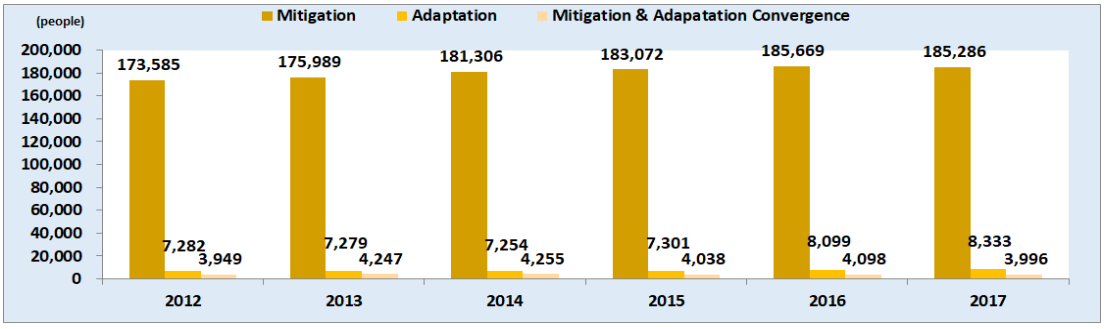


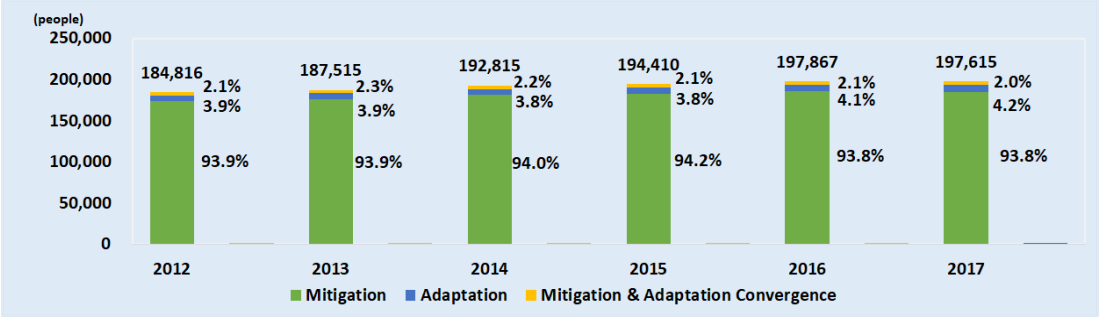
(unit: KRW million won)

Division	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
Mitigation	157,460,147	154,171,751	150,388,780	143,846,895	147,011,381	158,543,795	151,903,791	0.14%
Adaptation	9,144,645	9,162,623	8,794,060	8,001,183	8,142,253	8,472,677	8,619,573	-1.51%
Mitigation & Adaptation Convergence	5,015,886	4,493,561	4,443,908	4,530,053	4,403,338	4,366,067	4,542,136	-2.74%

The Number of Employees by Tech-division in the Climate Technology Industry from 2012 to 2017

- From 2012 to 2017, more than 90% of employees in the climate technology industry worked in the sector of mitigation.
- As of 2017, employees in the sector of mitigation accounted for 93.8% of the total climate industry. As the largest of the three sectors, 185,286 people are found to be working in the sector.
- The average annual growth rate of the number of employees in the climate technology sector was 1.31% in the sector of mitigation, 2.73% in the adaptation sector, and 0.24% in the convergence sector, showing an increasing tendency in general.
- The average number of employees working in the sector of mitigation between 2012 and 2017 was found to be 180,818. There were 7,591 workers in the adaptation sector and 4,097 workers in the convergence sector.



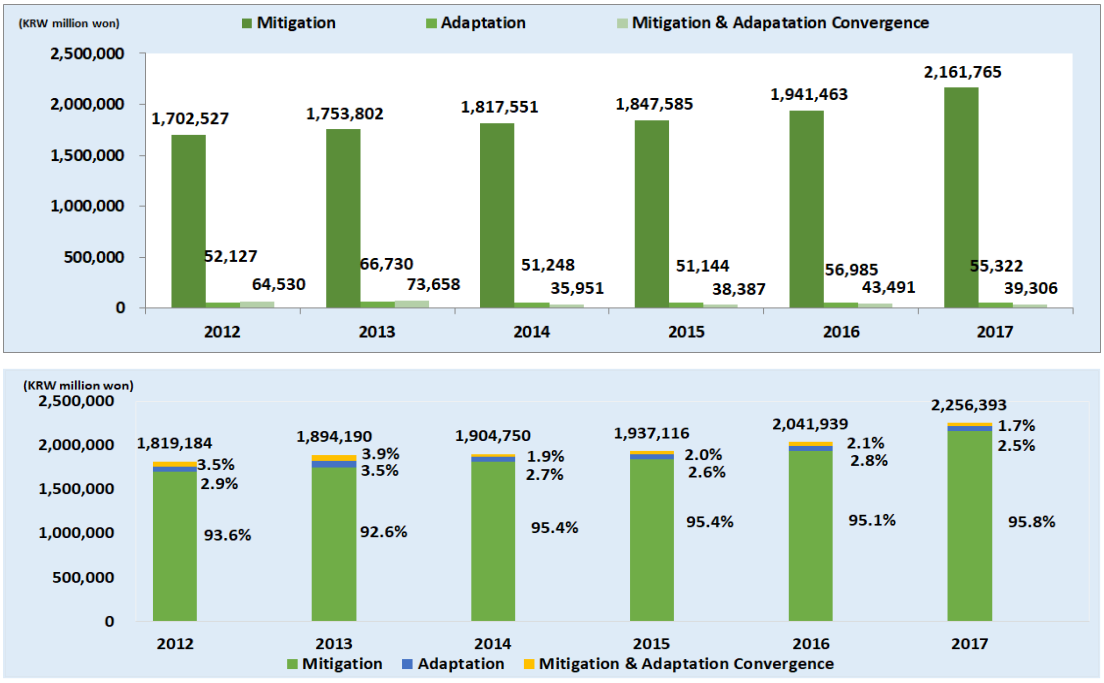


(unit: people)

Division	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
Mitigation	173,585	175,989	181,306	183,072	185,669	185,286	180,818	1.31%
Adaptation	7,282	7,279	7,254	7,301	8,099	8,333	7,591	2.73%
Mitigation & Adaptation Convergence	3,949	4,247	4,255	4,038	4,098	3,996	4,097	0.24%

The R&D Expenses by Tech-division in the Climate Technology Industry from 2012 to 2017

- R&D expenses of companies involved in the climate technology industry have continuously been invested in the sector of mitigation for more than 90% from 2012 to 2017.
- As of 2017, R&D investment in the sector of mitigation accounted for 95.8% of the total climate industry with the largest investment of 2,161 billion won among the three major sectors.
- The annual growth rate of R&D investment by sector in the climate technology is currently in an increasing trend with 3.34% in the sector of mitigation and 2.25% in the adaptation sector. In addition, the convergence sector recorded with -9.39%.
- From 2012 to 2017, an average amount of 1,870 billion won was invested in the sector of mitigation. In addition, 55 billion won was invested in the adaptation sector and 49 billion won for the convergence sector.



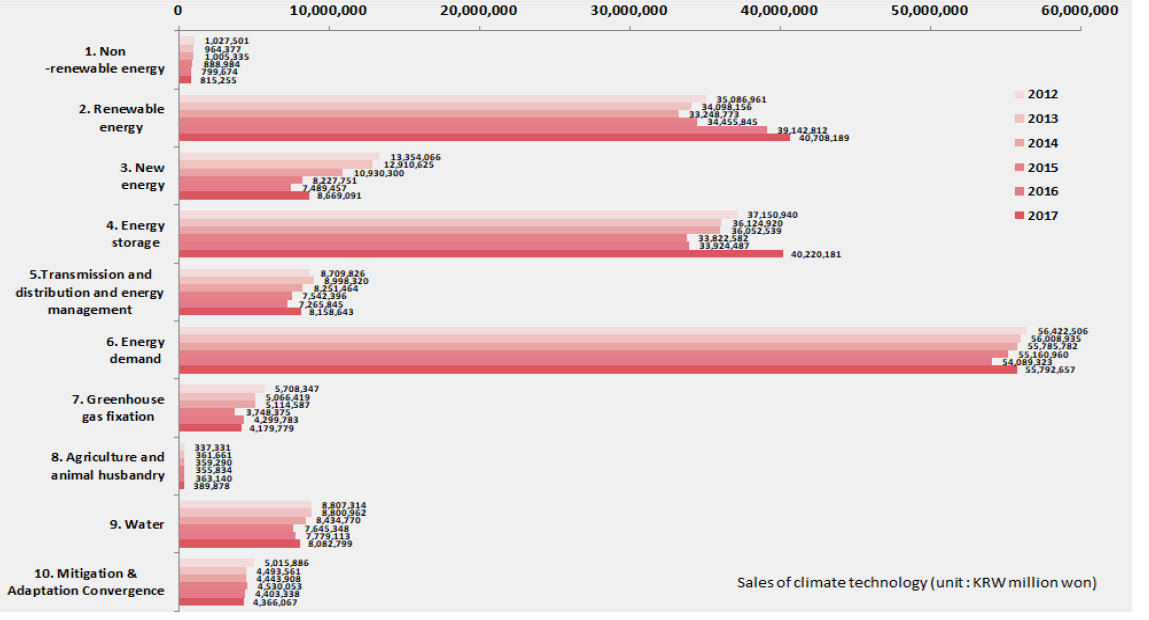
(unit: KRW million won)

Division	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
Mitigation	1,702,527	1,753,802	1,817,551	1,847,585	1,941,463	2,161,765	1,870,782	3.34%
Adaptation	52,127	66,730	51,248	51,144	56,985	55,322	55,593	2.25%
Mitigation & Adaptation Convergence	64,530	73,658	35,951	38,387	43,491	39,306	49,220	-9.39%

3.4.2.3. Status by Technology section in the Climate Technology Industry

Amount of Sales by Tech-section in the Climate Technology from 2012 to 2017

- Sales amount by Division turned out to be the greatest in the field of energy demand, followed by renewable energy and energy storage.
- Between 2012 and 2017, sales amount by in the climate technology was on the rise in the renewable energy sector and agricultural livestock sector at an annual average annual growth rate of 3.02% and 2.94%, while the rest of the sector was on the decline.



(unit: KRW million won)

Technology Section	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
1. Non-renewable energy	1,027,501	964,377	1,005,335	888,984	799,674	815,255	916,854	-4.52%
2. Renewable energy	35,086,961	34,098,156	33,248,773	34,455,845	39,142,812	40,708,189	36,123,456	3.02%
3. New energy	13,354,066	12,910,625	10,930,300	8,227,751	7,489,457	8,669,091	10,263,548	-8.28%
4. Energy storage	37,150,940	36,124,920	36,052,539	33,822,582	33,924,487	40,220,181	36,215,941	1.60%
5. Transmission and distribution and energy management	8,709,826	8,998,320	8,251,464	7,542,396	7,265,845	8,158,643	8,154,416	-1.30%
6. Energy demand	56,422,506	56,008,935	55,785,782	55,160,960	54,089,323	55,792,657	55,543,361	-0.22%
7. Greenhouse gas fixation	5,708,347	5,066,419	5,114,587	3,748,375	4,299,783	4,179,779	4,686,215	-6.04%
8. Agriculture and animal husbandry	337,331	361,661	359,290	355,834	363,140	389,878	361,189	2.94%
9. Water	8,807,314	8,800,962	8,434,770	7,645,348	7,779,113	8,082,799	8,258,384	-1.70%
10. Mitigation & Adaptation Convergence	5,015,886	4,493,561	4,443,908	4,530,053	4,403,338	4,366,067	4,542,136	-2.74%
Total	171,620,677	167,827,935	163,626,749	156,378,131	159,556,972	171,382,539	165,065,501	-0.03%

The Number of Employees by Tech-section in the Climate Technology from 2012 to 2017

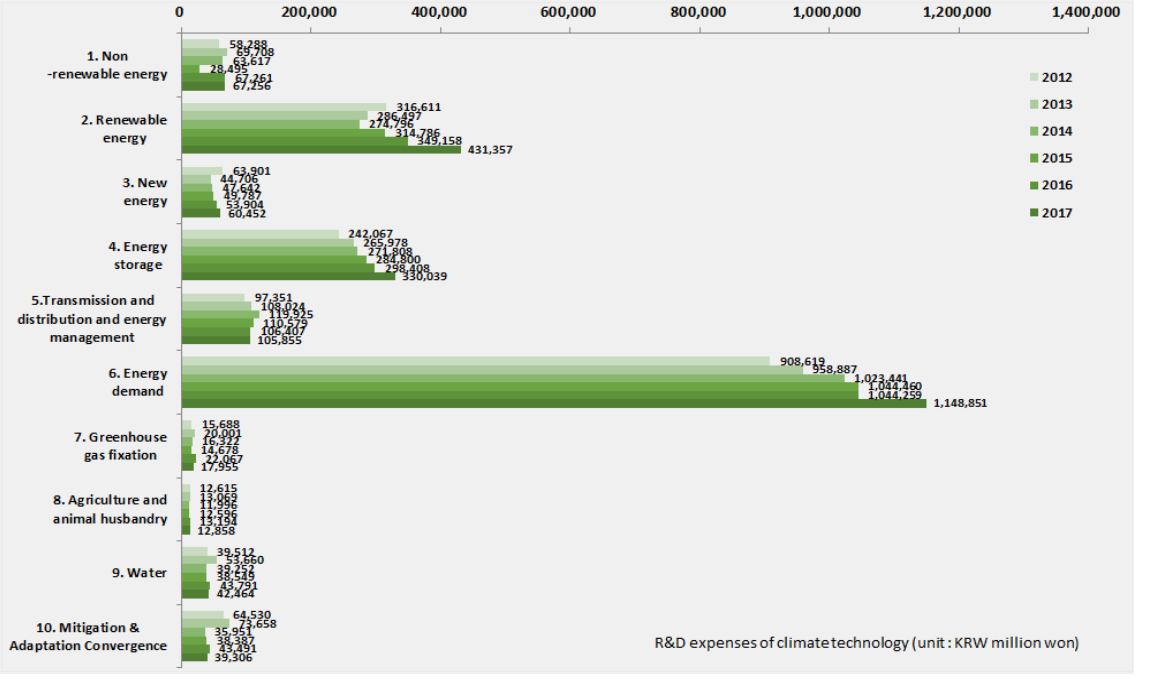
- The number of employees by Division was the highest in energy demand followed by renewable energy and energy storage.
- Between 2012 and 2017, the number of employees in the climate technology has decreased by -2.00% only in the Transmission and distribution and energy management sector and increased in all other technology sectors.

(unit: people)

Technology Section	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
1. Non-renewable energy	3,733	3,929	3,754	3,805	4,060	4,079	3,893	1.78%
2. Renewable energy	49,982	48,567	51,910	55,475	55,092	54,862	52,648	1.88%
3. New energy	3,942	3,900	3,953	3,566	3,977	3,992	3,888	0.26%
4. Energy storage	32,129	33,670	35,491	35,243	35,147	36,001	34,613	2.30%
5. Transmission and distribution and energy management	5,397	5,373	5,340	4,783	5,035	4,878	5,134	-2.00%
6. Energy demand	78,091	80,214	80,504	79,831	81,953	81,060	80,275	0.75%
7. Greenhouse gas fixation	310	338	355	368	406	415	365	5.96%
8. Agriculture and animal husbandry	1,346	1,486	1,415	1,448	1,516	1,630	1,473	3.91%
9. Water	5,936	5,794	5,839	5,853	6,584	6,703	6,118	2.46%
10. Mitigation & Adaptation Convergence	3,949	4,247	4,255	4,038	4,098	3,996	4,097	0.24%
Total	184,816	187,515	192,815	194,410	197,867	197,615	192,506	1.35%

Amount of R&D Expenses by Section in the Climate Technology from 2012 to 2017

- Amount of R&D expenses by Division was the highest in energy demand followed by renewable energy and energy storage.
- Between 2012 and 2017, the average annual growth rate of area specific investment in the R&D investment from climate technology was -1.10% in the new energy and -9.44% in the convergence sector, while the rest of the technology sectors was on the rise.



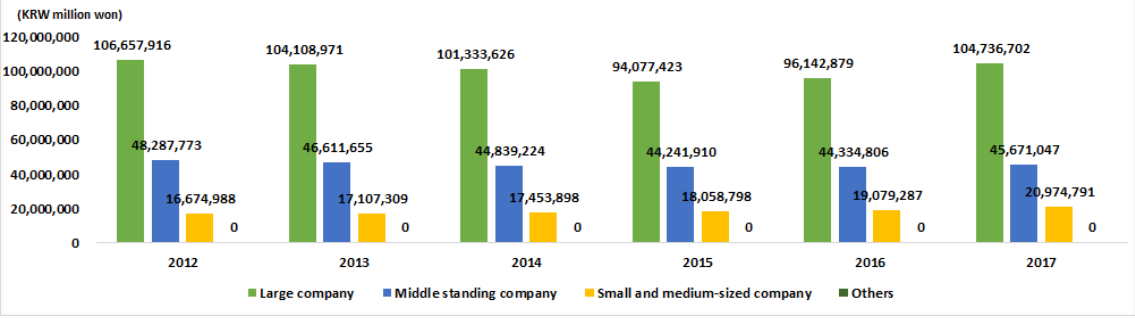
(unit: KRW million won)

Technology Section	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
1. Non-renewable energy	58,288	69,708	63,617	28,495	67,261	67,256	59,104	2.90%
2. Renewable energy	316,611	286,497	274,796	314,786	349,158	431,357	328,868	6.38%
3. New energy	63,901	44,706	47,642	49,787	53,904	60,452	53,399	-1.10%
4. Energy storage	242,067	265,978	271,808	284,800	298,408	330,039	282,183	6.40%
5. Transmission and distribution and energy management	97,351	108,024	119,925	110,579	106,407	105,855	108,024	1.69%
6. Energy demand	908,619	958,887	1,023,441	1,044,460	1,044,259	1,148,851	1,021,420	4.80%
7. Greenhouse gas fixation	15,688	20,001	16,322	14,678	22,067	17,955	17,785	2.74%
8. Agriculture and animal husbandry	12,615	13,069	11,996	12,596	13,194	12,858	12,721	0.38%
9. Water	39,512	53,660	39,252	38,549	43,791	42,464	42,871	1.45%
10. Mitigation & Adaptation Convergence	64,530	73,658	35,951	38,387	43,491	39,306	49,220	-9.44%
Total	1,819,184	1,894,190	1,904,750	1,937,116	2,041,939	2,256,393	1,975,595	4.40%

3.4.2.4. Status by Business Size in the Climate Technology Industry

Amount of Sales by Business Size in the Climate Technology Industry from 2012 to 2017

- Between 2012 and 2017, sales amount at large companies increased by -0.36% on average, while one of middle standing companies was -1.11% and those of small and medium-sized companies were 4.70%.
- According to the sales status by business size in the climate technology, the sales amount of large companies and middle standing companies has been decreasing in the area of Mitigation and adaptation.
- On the other hand, the sales amount of small and medium-sized companies increased in all the Mitigation, Adaptation and Mitigation & Adaptation Convergence.

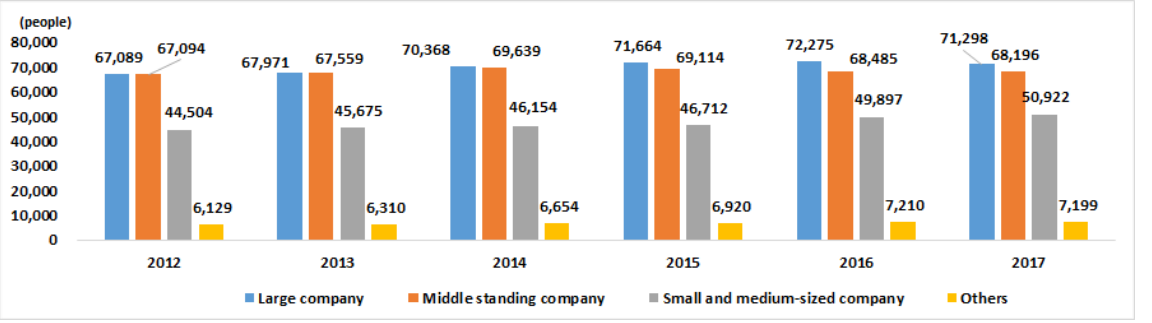


(unit: KRW million won)

Business Size	Division	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
Large company	Mitigation	98,407,543	95,702,904	93,158,934	86,735,370	88,627,945	96,894,496	93,254,532	-0.31%
	Adaptation	7,423,219	7,496,556	7,192,742	6,399,773	6,542,637	6,769,533	6,970,743	-1.83%
	Mitigation & Adaptation Convergence	827,155	909,512	981,950	942,280	972,297	1,072,672	950,978	5.34%
	Total	106,657,916	104,108,971	101,333,626	94,077,423	96,142,879	104,736,702	101,176,253	-0.36%
Middle standing company	Mitigation	44,122,525	43,160,320	41,595,586	40,929,202	41,208,015	42,666,705	42,280,392	-0.67%
	Adaptation	468,212	410,827	373,838	348,929	342,990	396,201	390,166	-3.28%
	Mitigation & Adaptation Convergence	3,697,036	3,040,508	2,869,801	2,963,779	2,783,801	2,608,141	2,993,844	-6.74%
	Total	48,287,773	46,611,655	44,839,224	44,241,910	44,334,806	45,671,047	45,664,402	-1.11%
Small and medium -sized company	Mitigation	14,930,079	15,308,528	15,634,260	16,182,323	17,175,421	18,982,594	16,368,867	4.92%
	Adaptation	1,253,215	1,255,240	1,227,480	1,252,481	1,256,626	1,306,943	1,258,664	0.84%
	Mitigation & Adaptation Convergence	491,695	543,541	592,157	623,994	647,240	685,254	597,314	6.86%
	Total	16,674,988	17,107,309	17,453,898	18,058,798	19,079,287	20,974,791	18,224,845	4.70%

Number of Employees by Business Size in the Climate Technology Industry from 2012 to 2017

- As for the number of employees in large companies between 2012 and 2017, an annual average growth rate turned out to be 1.22%, while one of middle standing companies and small and medium-sized companies increased by 0.33% and 2.73%, respectively.
- According to the status of the number of employees by business size by climate technology, it was found that the number of employees of large, middle standing and small and medium-sized companies in the sector of Mitigation was all on the rise.
- On the other hand, the number of employees of both large and small and medium-sized companies has decreased in the sector of Mitigation.

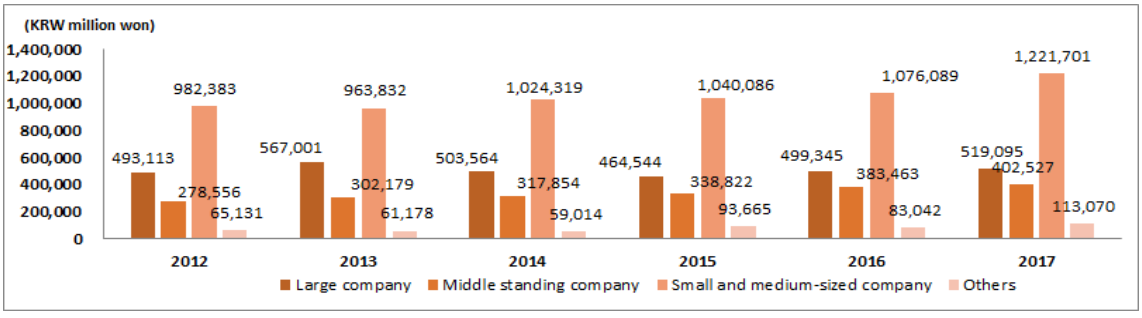


(unit: people)

Business Size	Division	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
Large company	Mitigation	65,880	66,682	69,105	70,386	70,968	69,988	68,835	1.22%
	Adaptation	72	71	71	69	98	101	80	7.10%
	Mitigation & Adaptation Convergence	1,137	1,218	1,192	1,209	1,209	1,209	1,196	1.23%
	Total	67,089	67,971	70,368	71,664	72,275	71,298	70,111	1.22%
Middle standing company	Mitigation	64,529	64,822	66,978	66,603	65,984	65,794	65,785	0.39%
	Adaptation	449	451	436	436	477	507	459	2.47%
	Mitigation & Adaptation Convergence	2,116	2,286	2,225	2,075	2,024	1,895	2,104	-2.18%
	Total	67,094	67,559	69,639	69,114	68,485	68,196	68,348	0.33%
Small and medium -sized company	Mitigation	37,281	38,412	38,812	39,400	41,742	42,542	39,698	2.68%
	Adaptation	6,619	6,615	6,603	6,652	7,376	7,579	6,907	2.75%
	Mitigation & Adaptation Convergence	604	648	740	660	780	800	705	5.79%
	Total	44,504	45,675	46,154	46,712	49,897	50,922	47,311	2.73%
Non-profit organizations such as research institutes	Mitigation	5,895	6,073	6,412	6,683	6,975	6,963	6,500	3.39%
	Adaptation	142	142	144	144	149	145	144	0.42%
	Mitigation & Adaptation Convergence	92	95	99	93	85	92	93	-0.15%
	Total	6,129	6,310	6,654	6,920	7,210	7,199	6,737	3.27%

Amount of R&D Expenses by Business Size in the Climate Technology Industry from 2012 to 2017

- Between 2012 and 2017, investment in R&D expenses by large companies increased by 1.03%, while one of the middle standing companies and small and medium-sized companies increased by 7.64% and 4.46%, respectively.
- According to the status of R&D expenses by business size by climate technology, it has seen that R&D investment by large, middle standing and small and medium-sized companies has been increasing in the sector of Mitigation.
- On the other hand, R&D investment in the sector of adaptation has been shown to be decreasing in large and middle standing companies, while the number of small and medium-sized companies has been increasing.



(unit: KRW million won)

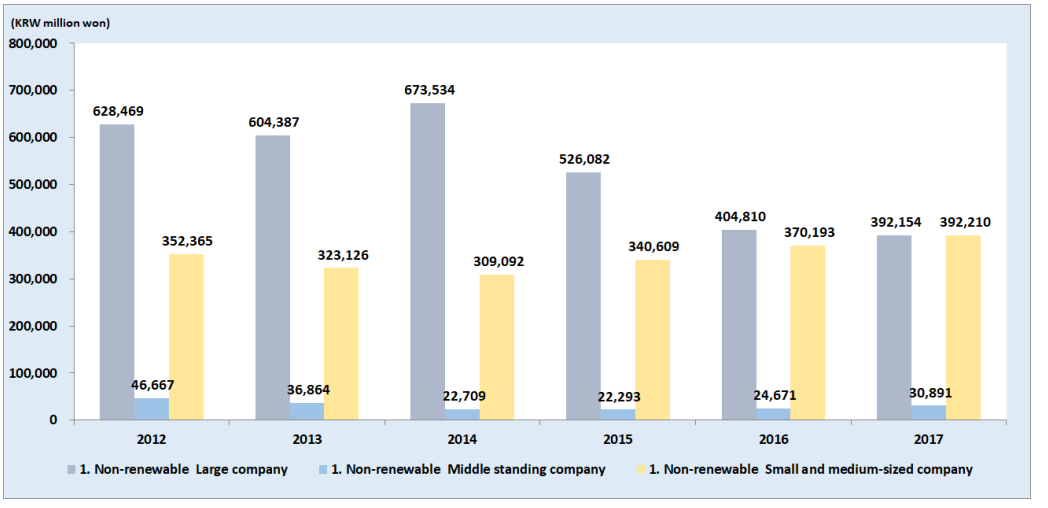
Business Size	Division	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
Large company	Mitigation	436,409	504,826	481,650	439,816	475,855	498,683	472,873	2.70%
	Adaptation	6,384	8,599	5,228	7,034	5,371	5,121	6,289	-4.31%
	Mitigation & Adaptation Convergence	50,320	53,576	16,686	17,694	18,119	15,292	28,615	-21.20%
	Total	493,113	567,001	503,564	464,544	499,345	519,095	505,513	1.03%
Middle standing company	Mitigation	263,234	283,271	299,126	318,534	358,289	378,032	316,748	7.51%
	Adaptation	6,357	6,894	6,659	7,045	7,266	7,262	6,914	2.70%
	Mitigation & Adaptation Convergence	8,965	12,014	12,069	13,243	17,908	17,232	13,572	13.96%
	Total	278,556	302,179	317,854	338,822	383,463	402,527	324,175	7.64%
Small and medium -sized company	Mitigation	937,803	904,550	977,788	996,051	1,024,967	1,172,600	1,002,294	4.57%
	Adaptation	39,335	51,213	39,336	37,012	44,277	42,866	42,340	1.73%
	Mitigation & Adaptation Convergence	5,245	8,068	7,194	7,022	6,844	6,235	6,768	3.52%
	Total	982,383	963,832	1,024,319	1,040,086	1,076,089	1,221,701	1,017,342	4.46%
Non-profit organizations such as research institutes	Mitigation	65,080	61,155	58,987	93,183	82,352	112,450	78,868	11.56%
	Adaptation	51	23	25	53	71	73	49	7.47%
	Mitigation & Adaptation Convergence	0	0	2	428	619	547	266	549.11%
	Total	65,131	61,178	59,014	93,665	83,042	113,070	72,406	11.66%

3.4.2.5. Status by Technology Section and Business Size in the Climate Technology Industry

▶ Amount of Sales by Technology Section and Business Size in the Climate Technology from 2012 to 2017

1. Amount of sales from non-renewable energy technology related industry by business size

- From 2012 to 2017, the average annual sales growth rate of nuclear power, nuclear fusion, and clean thermal power generation and efficiency related industries was -4.52%, indicating an overall decline.
- The market size of non-renewable energy sector is estimated to be 916 billion won for the past six years.
- Sales amount at large companies and middle standing companies was on the decline, while the one at small and medium-sized companies increased as follows; large companies by -9.00%, middle standing companies by -7.92%, and small and medium-sized companies by 2.17%.
- Large companies have an average sales amount of 538 billion won, while middle standing companies and small and medium-sized companies have an average sales amount of 30 billion won and 347 billion won, respectively.

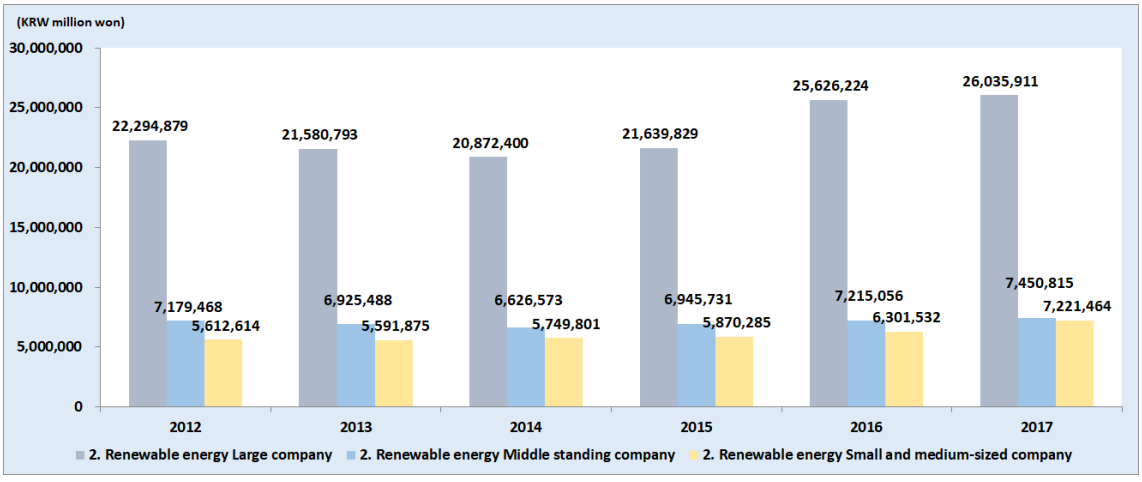


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
1. Non-renewable energy	Large company	628,469	604,387	673,534	526,082	404,810	392,154	538,239	-9.00%
	Middle standing company	46,667	36,864	22,709	22,293	24,671	30,891	30,683	-7.92%
	Small and medium-sized company	352,365	323,126	309,092	340,609	370,193	392,210	347,932	2.17%
	Total	1,027,501	964,377	1,005,335	888,984	799,674	815,255	916,854	-4.52%

2. Amount of sales from renewable energy technology related industry by business size

- The annual growth rate of sales in the renewable energy related industries such as solar power, solar heat, wind power, geothermal power, hydroelectric power, marine energy, bio energy, and waste power generation was 3.02% from 2012 to 2017, indicating an overall rise.
- The market size of renewable energy sector is estimated to be an average of 36,123 billion won over the past six years.
- Large companies, middle standing companies, and small and medium-sized companies are all on the rise of 3.15%, 0.74% and 5.17%, respectively.
- Large companies have an average sales amount of 23,008 billion won, while middle standing companies and small and medium-sized companies have an average sales amount of 7,057 billion won and 6,057 billion won, respectively.

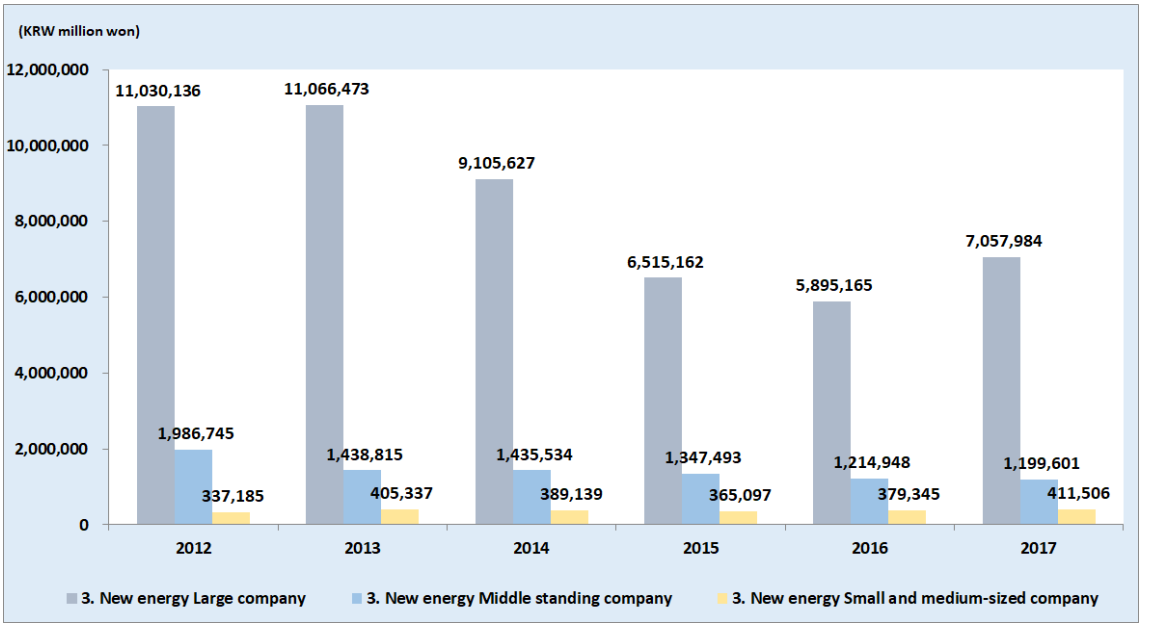


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
2. Renewable energy	Large company	22,294,879	21,580,793	20,872,400	21,639,829	25,626,224	26,035,911	23,008,339	3.15%
	Middle standing company	7,179,468	6,925,488	6,626,573	6,945,731	7,215,056	7,450,815	7,057,188	0.74%
	Small and medium-sized company	5,612,614	5,591,875	5,749,801	5,870,285	6,301,532	7,221,464	6,057,928	5.17%
	Total	35,086,961	34,098,156	33,248,773	34,455,845	39,142,812	40,708,189	36,123,456	3.02%

3. Amount of sales from new energy technology related industry by business size

- Sales amount in the new energy industry related to hydrogen manufacturing and fuel cells continued to fall from 2012 to 2017, recording an average annual growth rate of -8.28%.
- The market size of the new energy sector over the past six years was estimated at 10,263 billion won on average.
- Small and medium-sized companies experienced a small annual increase of 4.06% in 2013 and 2016, but both large and middle standing companies decreased by -8.54% and -9.60% respectively.
- Large companies have an average sales amount of 8,445 billion won, while middle standing companies and small and medium-sized companies have an average sales amount of 1,437 billion won and 381 billion won, respectively.

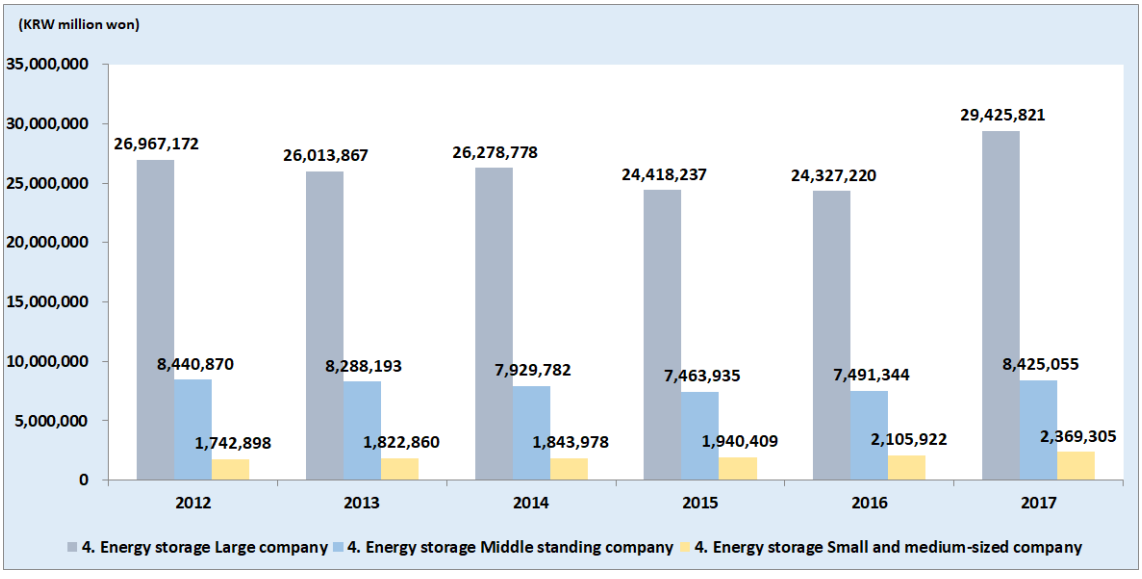


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
3. New energy	Large company	11,030,136	11,066,473	9,105,627	6,515,162	5,895,165	7,057,984	8,445,091	-8.54%
	Middle standing company	1,986,745	1,438,815	1,435,534	1,347,493	1,214,948	1,199,601	1,437,189	-9.60%
	Small and medium-sized company	337,185	405,337	389,139	365,097	379,345	411,506	381,268	4.06%
	Total	13,354,066	12,910,625	10,930,300	8,227,751	7,489,457	8,669,091	10,263,548	-8.28%

4. Amount of sales from energy storage technology related industry by business size

- The average annual sales amount in the energy storage industry related to electric power storage and hydrogen storage has fallen by 1.60% between 2012 and 2017, indicating an overall decline.
- The market size of the energy sector over the past six years was estimated at 36,215 billion won on average.
- Large companies and middle standing companies are falling by 1.76% and -0.04%, respectively, but small and medium-sized companies are growing steadily over the past six years at 6.33%.
- Large companies have an average sales amount of 26,238 billion won, while middle standing companies and small and medium-sized companies have an average sales amount of 8,006 billion won and 1,970 billion won, respectively.

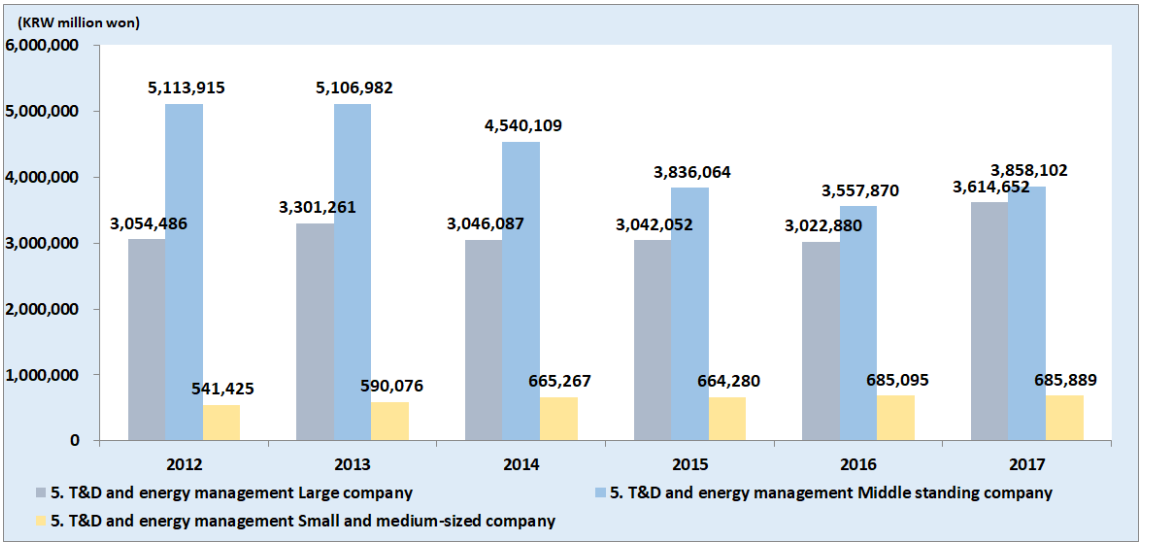


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
4. Energy storage	Large company	26,967,172	26,013,867	26,278,778	24,418,237	24,327,220	29,425,821	26,238,516	1.76%
	Middle standing company	8,440,870	8,288,193	7,929,782	7,463,935	7,491,344	8,425,055	8,006,530	-0.04%
	Small and medium-sized company	1,742,898	1,822,860	1,843,978	1,940,409	2,105,922	2,369,305	1,970,896	6.33%
	Total	37,150,940	36,124,920	36,052,539	33,822,582	33,924,487	40,220,181	36,215,941	1.60%

5. Amount of sales from transmission and distribution and energy management technology related industry by business size

- The average annual sales amount in the Transmission and distribution and energy management industry related to power transmission and distribution systems and electronic intelligent equipment turned out to be -1.30% between 2012 and 2017. The overall trend has been declining, except for the year of 2013.
- The market size of the Transmission and distribution and energy management sector over the past six years was estimated at 8,154 billion won on average.
- Large companies are showing a constant level of sales amount at 3.43%. Middle standing companies are showing an decrease by 5.48% due to the influence of 2014 and 2015, while small and medium-sized companies are growing small, but increasing steadily by 4.84%.
- Large companies have an average sales amount of 3,180 billion won, while middle standing companies and small and medium-sized companies have an average sales amount of 4,335 billion won and 638 billion won, respectively.

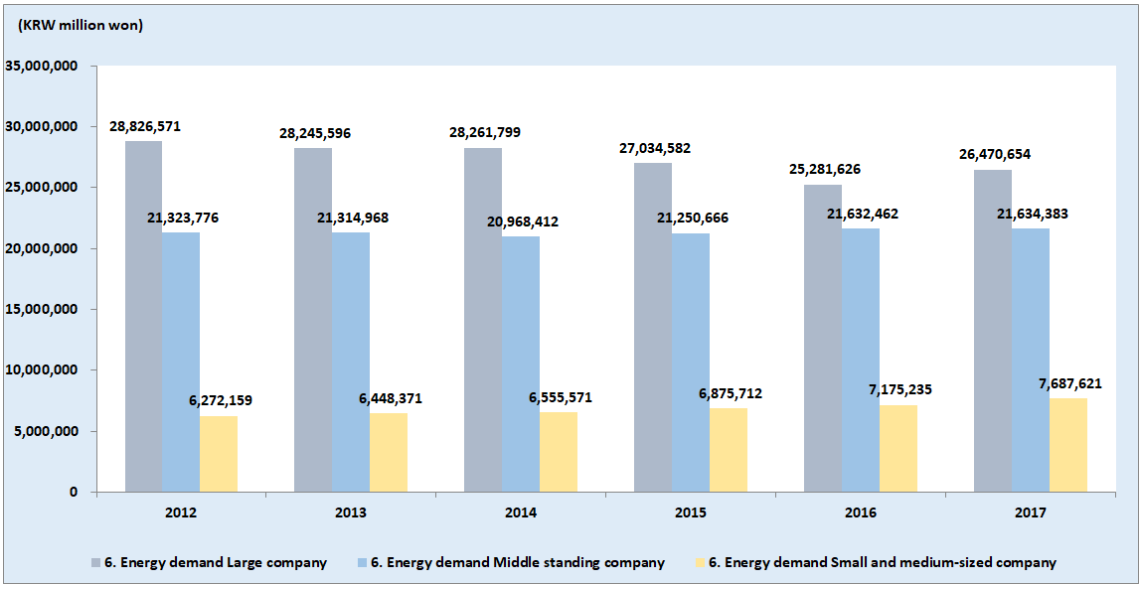


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
5. Transmission and distribution and energy management	Large company	3,054,486	3,301,261	3,046,087	3,042,052	3,022,880	3,614,652	3,180,236	3.43%
	Middle standing company	5,113,915	5,106,982	4,540,109	3,836,064	3,557,870	3,858,102	4,335,507	-5.48%
	Small and medium-sized company	541,425	590,076	665,267	664,280	685,095	685,889	638,672	4.84%
	Total	8,709,826	8,998,320	8,251,464	7,542,396	7,265,845	8,158,643	8,154,416	-1.30%

6. Amount of sales from energy demand technology related industry by business size

- The average annual sales amount of the energy demand industry related to transportation efficiency, industrial efficiency, and construction efficiency has declined slightly by -0.22% between 2012 and 2017.
- The market size of the energy demand sector over the past six years was estimated at 55,543 billion won on average.
- Except for small and medium-sized companies, middle standing companies recording an increase of 4.15%, 0.29%, large companies have been declining by -1.69%, respectively.
- Large companies have an average sales amount of 27,353 billion won, while middle standing companies and small and medium-sized companies have an average sales amount of 21,354 billion won and 6,835 billion won, respectively.

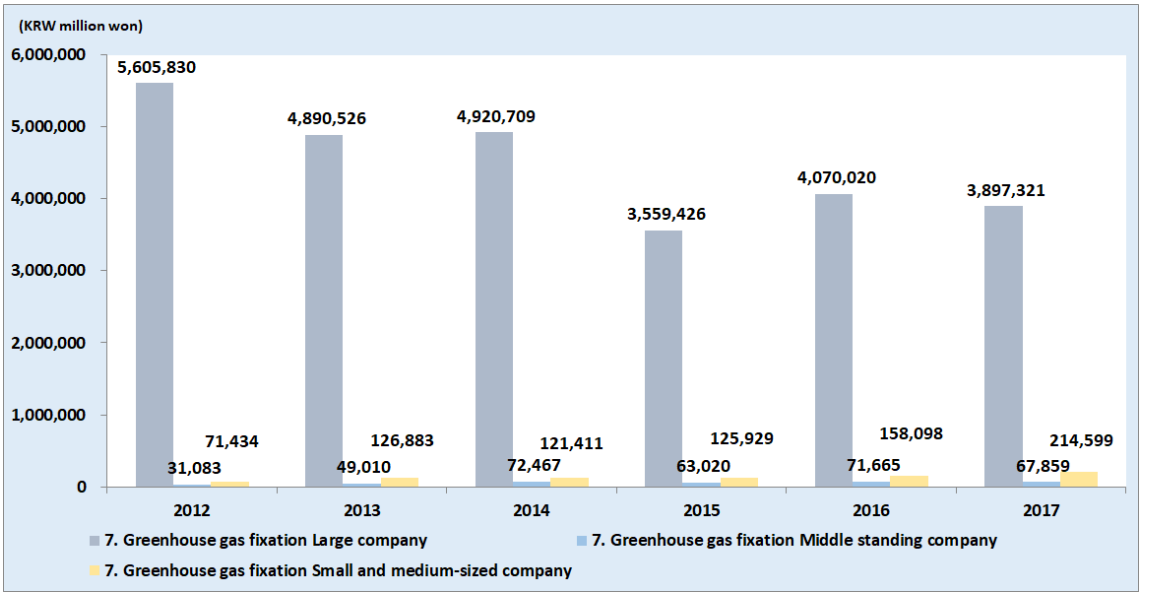


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
6. Energy demand	Large company	28,826,571	28,245,596	28,261,799	27,034,582	25,281,626	26,470,654	27,353,471	-1.69%
	Middle standing company	21,323,776	21,314,968	20,968,412	21,250,666	21,632,462	21,634,383	21,354,111	0.29%
	Small and medium-sized company	6,272,159	6,448,371	6,555,571	6,875,712	7,175,235	7,687,621	6,835,778	4.15%
	Total	56,422,506	56,008,935	55,785,782	55,160,960	54,089,323	55,792,657	55,543,361	-0.22%

7. Amount of sales from greenhouse gas fixation technology related industry by business size

- The average annual sales amount of the greenhouse gas fixation industry related to CCUS and Non-CO_2 was -6.04% from 2012 to 2017, indicating an overall decline.
- The market size of the greenhouse gas fixation sector over the past six years was estimated at 4,686 billion won on average.
- Large companies showed a negative average annual growth rates of -7.01%, while both middle standing companies and small and medium-sized companies showed an increase of 16.90% and 24.61%, respectively.
- Large companies have an average sales amount of 4,490 billion won, while middle standing companies and small and medium-sized companies have an average sales amount of 59 billion won and 136 billion won, respectively.

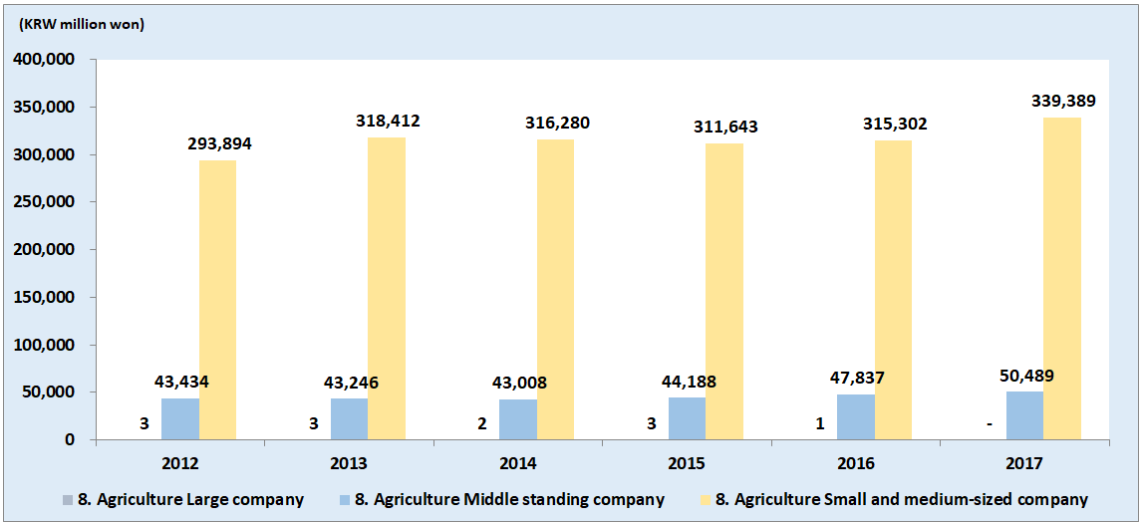


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
7. Greenhouse gas fixation	Large company	5,605,830	4,890,526	4,920,709	3,559,426	4,070,020	3,897,321	4,490,639	-7.01%
	Middle standing company	31,083	49,010	72,467	63,020	71,665	67,859	59,184	16.90%
	Small and medium-sized company	71,434	126,883	121,411	125,929	158,098	214,599	136,392	24.61%
	Total	5,708,347	5,066,419	5,114,587	3,748,375	4,299,783	4,179,779	4,686,215	-6.04%

8. Amount of sales from agriculture and animal husbandry technology related industry by business size

- The average annual sales of the agriculture and animal husbandry industry related to genetic resources and genetic improvement, crop cultivation and production, and livestock disease management was recorded to be 2.94% between 2012 and 2017, indicating an overall rise.
- The market size of the agriculture and animal husbandry sector over the past six years was estimated at 361 billion won on average.
- Large companies accounted for an annual average growth rate of -100.00%, but the agricultural and animal husbandry sector accounts for a small portion of sales amount. The average annual growth rate of middle standing companies was 3.06% and that of small and medium-sized companies was 2.92%.
- Large companies have an average sales amount of 2 million won, while middle standing companies and small and medium-sized companies have an average sales amount of 45 billion won and 315 billion won, respectively.

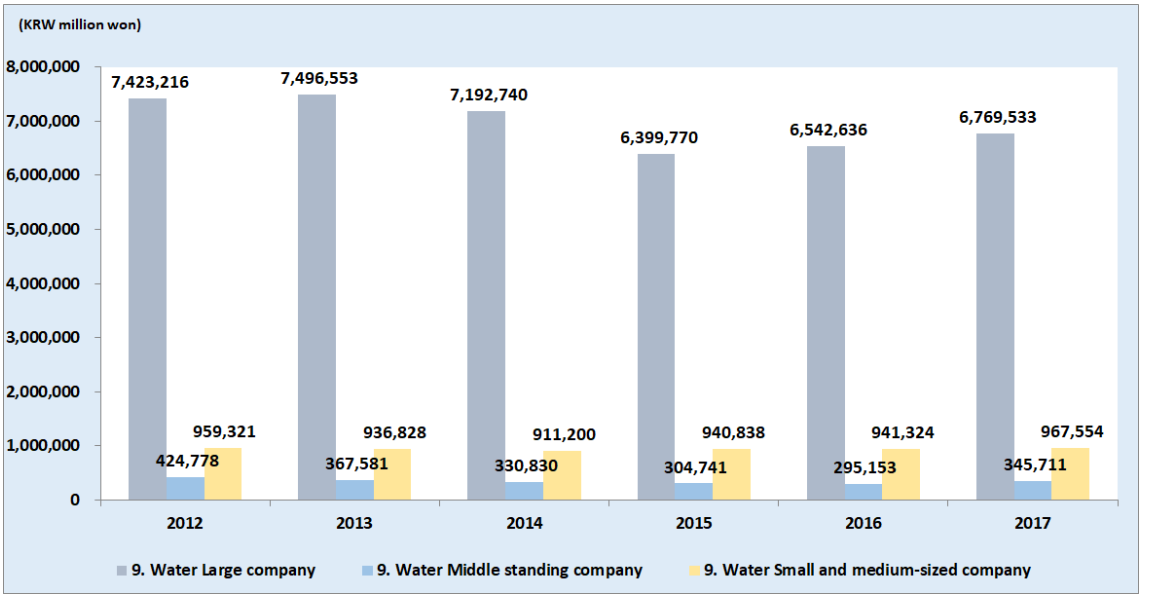


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
8. Agriculture and animal husbandry	Large company	3	3	2	3	1	-	2	-100.00%
	Middle standing company	43,434	43,246	43,008	44,188	47,837	50,489	45,367	3.06%
	Small and medium-sized company	293,894	318,412	316,280	311,643	315,302	339,389	315,820	2.92%
	Total	337,331	361,661	359,290	355,834	363,140	389,878	361,189	2.94%

9. Amount of sales from water technology related industry by business size

- The average annual sales amount of water-related industries such as water system, hydro ecosystem, securing and supplying of water resources, water treatment, and water disaster management was reduced by -1.70% from 2012 to 2017, indicating an overall decline.
- The market size of the water sector over the past six years was estimated at 8,258 billion won on average.
- Large companies, middle standing companies are all on the decline by -1.83%, -4.04%, and small and medium-sized companies are on the rise of 0.17%, respectively.
- Large companies have an average sales amount of 6,970 billion won, while middle standing companies and small and medium-sized companies have an average sales amount of 344 billion won and 942 billion won, respectively.

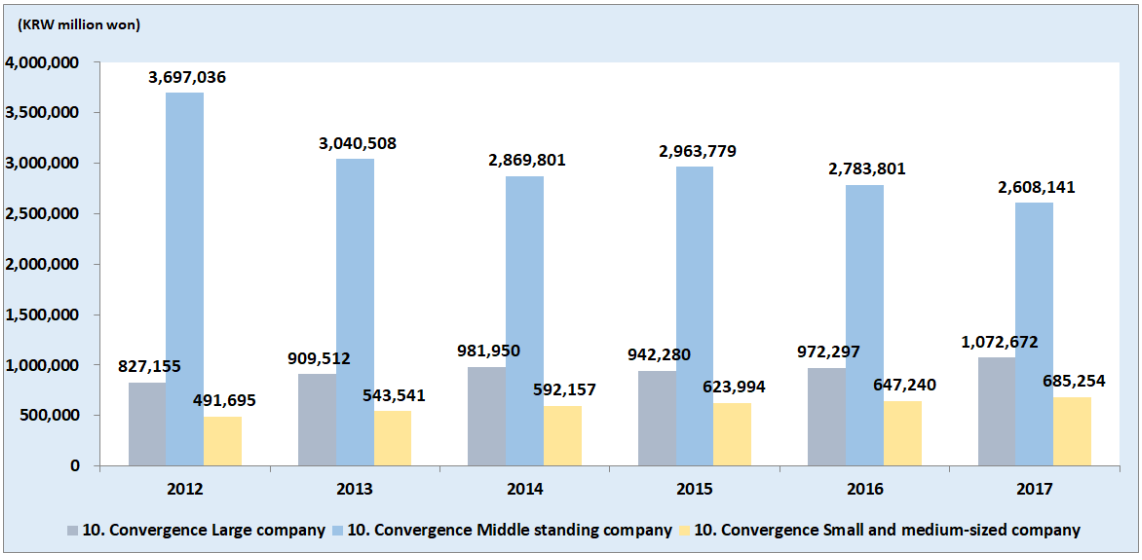


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
9. Water	Large company	7,423,216	7,496,553	7,192,740	6,399,770	6,542,636	6,769,533	6,970,741	-1.83%
	Middle standing company	424,778	367,581	330,830	304,741	295,153	345,711	344,799	-4.04%
	Small and medium-sized company	959,321	936,828	911,200	940,838	941,324	967,554	942,844	0.17%
	Total	8,807,314	8,800,962	8,434,770	7,645,348	7,779,113	8,082,799	8,258,384	-1.70%

10. Amount of sales from Mitigation & Adaptation Convergence technology related industry by business size

- The average annual sales amount of Mitigation & Adaptation Convergence related industries such as new renewable energy hybrid, low-power consumer electronics, energy harvesting, artificial photosynthesis, and climate technology as a part of other classification systems that are difficult to deal with was reduced by -2.74% from 2012 to 2017, indicating an overall decline.
- The market size of the Mitigation & Adaptation Convergence sector over the past six years was estimated at 4,542 billion won on average.
- The growth rate for large companies and small and medium-sized companies is 5.34% and 6.86% respectively, while the one for middle standing companies declined by -6.74%.
- Large companies have an average sales amount of 950 billion won, while middle standing companies and small and medium-sized companies have an average sales amount of 2,993 billion won and 597 billion won, respectively.



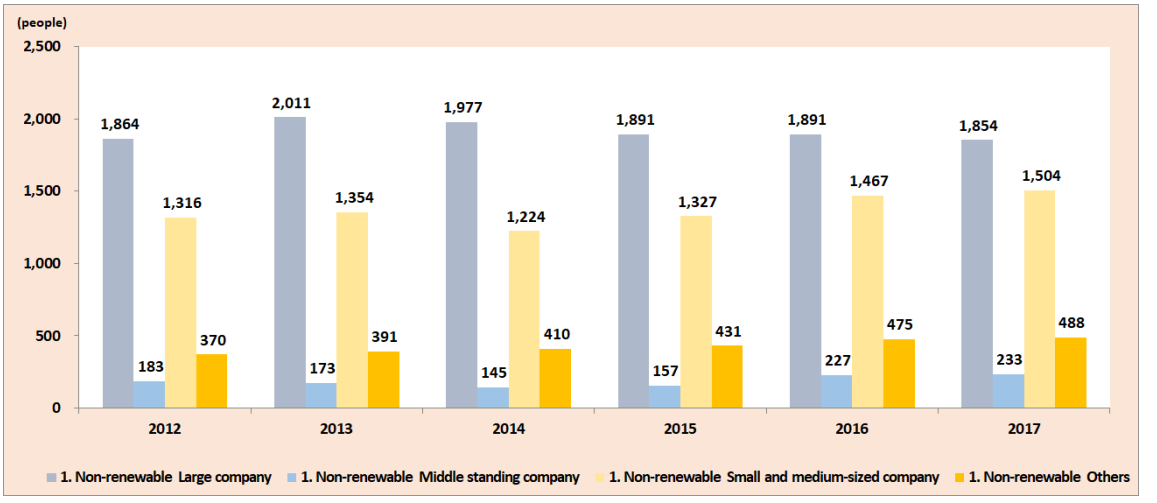
(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
10. Mitigation & Adaptation Convergence	Large company	827,155	909,512	981,950	942,280	972,297	1,072,672	950,978	5.34%
	Middle standing company	3,697,036	3,040,508	2,869,801	2,963,779	2,783,801	2,608,141	2,993,844	-6.74%
	Small and medium-sized company	491,695	543,541	592,157	623,994	647,240	685,254	597,314	6.86%
	Total	5,015,886	4,493,561	4,443,908	4,530,053	4,403,338	4,366,067	4,542,136	-2.74%

The Number of Employees by Business Size in the Climate Technology from 2012 to 2017

1. The number of employees by business size in non-renewable energy technology related industry

- Between 2012 and 2017, the number of employees in non-renewable energy industry increased by 1.78%, indicating an overall rise.
- The number of employees in non-renewable energy sector over the past six years was estimated with an annual average of 3,893.
- Large companies, middle standing companies, small and medium-sized company, and non-profit organizations (others) including other research institutes are all on the rise by -0.11%, 4.95%, 2.71%, and 5.66%, respectively.
- There are an annual average of 1,915 workers in large companies, 186 in middle standing companies, 1,365 in small and medium-sized companies, and 427 in others.



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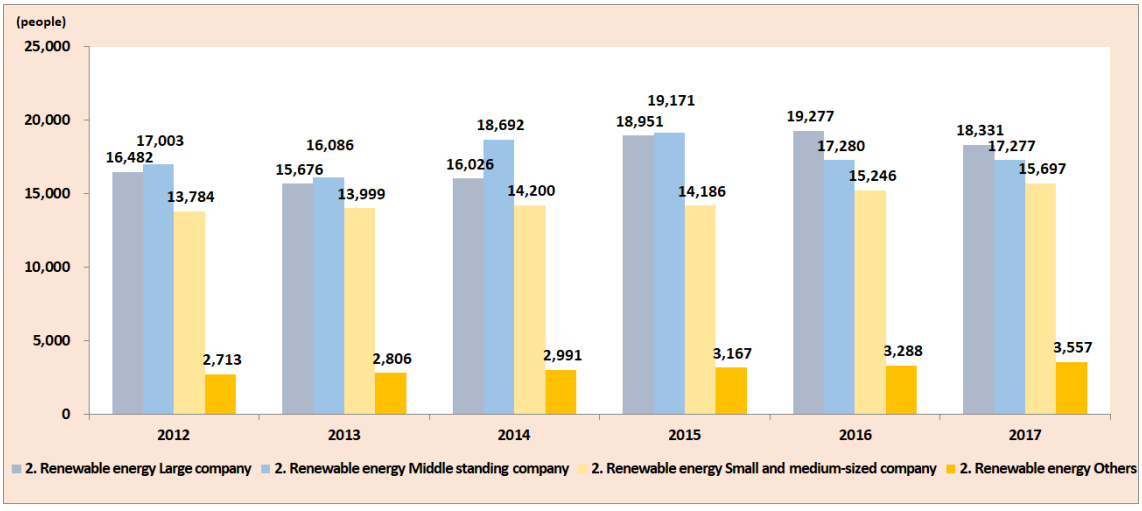
Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
1. Non-renewable energy	Large company	1,864	2,011	1,977	1,891	1,891	1,854	1,915	-0.11%
	Middle standing company	183	173	145	157	227	233	186	4.95%
	Small and medium-sized company	1,316	1,354	1,224	1,327	1,467	1,504	1,365	2.71%
	Others	370	391	410	431	475	488	427	5.66%
	Total	3,733	3,929	3,754	3,805	4,060	4,079	3,893	1.78%

2. The number of employees by business size in renewable energy technology related industry

- Between 2012 and 2017, the number of employees in renewable energy industry increased by 1.88%, indicating an overall rise.
- The number of employees in renewable energy sector over the past six years was estimated at an annual average of 52,648.
- Large companies, middle standing companies, small and medium-sized companies, and others accounted for 2.15%, 0.32%, 2.63%, and 5.57%, respectively, with an overall growing trend.
- There are an annual average of 17,457 workers in large companies, 17,585 in middle standing companies, 14,519 in small and medium-sized companies, and 3,087 in others.



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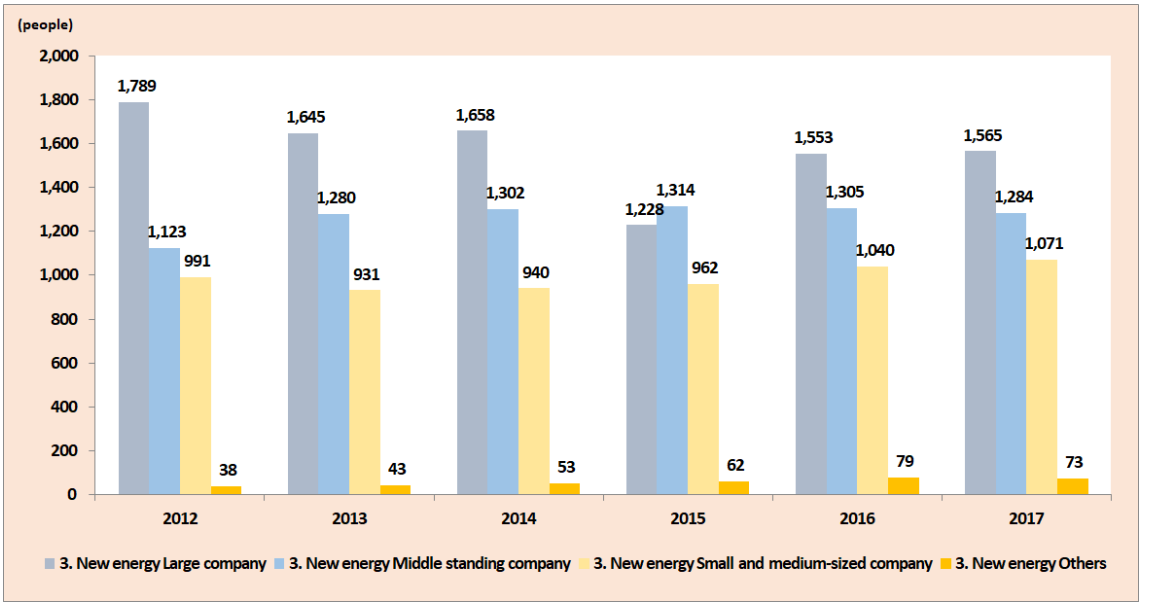
Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
2. Renewable energy	Large company	16,482	15,676	16,026	18,951	19,277	18,331	17,457	2.15%
	Middle standing company	17,003	16,086	18,692	19,171	17,280	17,277	17,585	0.32%
	Small and medium-sized company	13,784	13,999	14,200	14,186	15,246	15,697	14,519	2.63%
	Others	2,713	2,806	2,991	3,167	3,288	3,557	3,087	5.57%
	Total	49,982	48,567	51,910	55,475	55,092	54,862	52,648	1.88%

3. The number of employees by business size in new energy technology related industry

- Between 2012 and 2017, the number of employees in new energy industry increased by 0.26%, indicating an overall rise.
- The number of employees in new energy sector over the past six years was estimated at an annual average of 3,888.
- Large corporations, middle standing companies, small and medium-sized companies, and others were recorded with -2.64%, 2.71%, 1.55%, and 14.04%, respectively. The non-profit sector, such as other research institutes, was recorded with a significant increase.
- There are an annual average of 1,573 workers in large companies, 1,268 in middle standing companies, 989 in small and medium-sized companies, and 58 in others.



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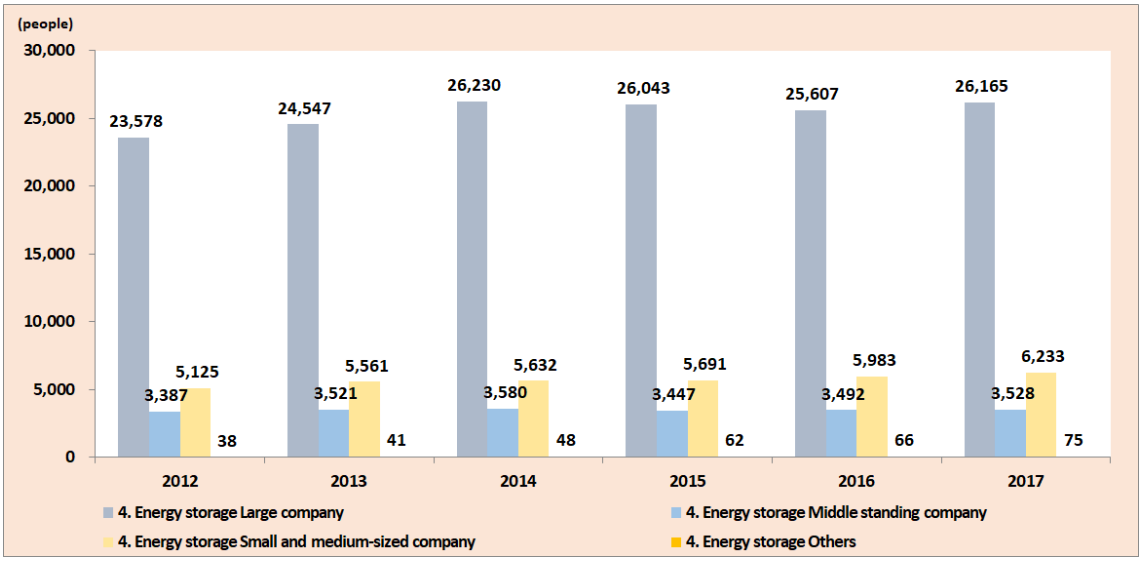
Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
3. New energy	Large company	1,789	1,645	1,658	1,228	1,553	1,565	1,573	-2.64%
	Middle standing company	1,123	1,280	1,302	1,314	1,305	1,284	1,268	2.71%
	Small and medium-sized company	991	931	940	962	1,040	1,071	989	1.55%
	Others	38	43	53	62	79	73	58	14.04%
	Total	3,942	3,900	3,953	3,566	3,977	3,992	3,888	0.26%

4. The number of employees by business size in energy storage technology related industry

- Between 2012 and 2017, the number of employees in energy storage industry increased by 2.30%, indicating an overall rise.
- The number of employees in energy storage sector over the past six years was estimated at an annual average of 34,613.
- Large companies, middle standing companies, small and medium-sized companies, and others were all on the rise of 2.10%, 0.82%, 3.99%, and 14.66%, respectively.
- There are an annual average of 25,362 workers in large companies, 3,492 in middle standing companies, 5,704 in small and medium-sized companies, and 55 in others.



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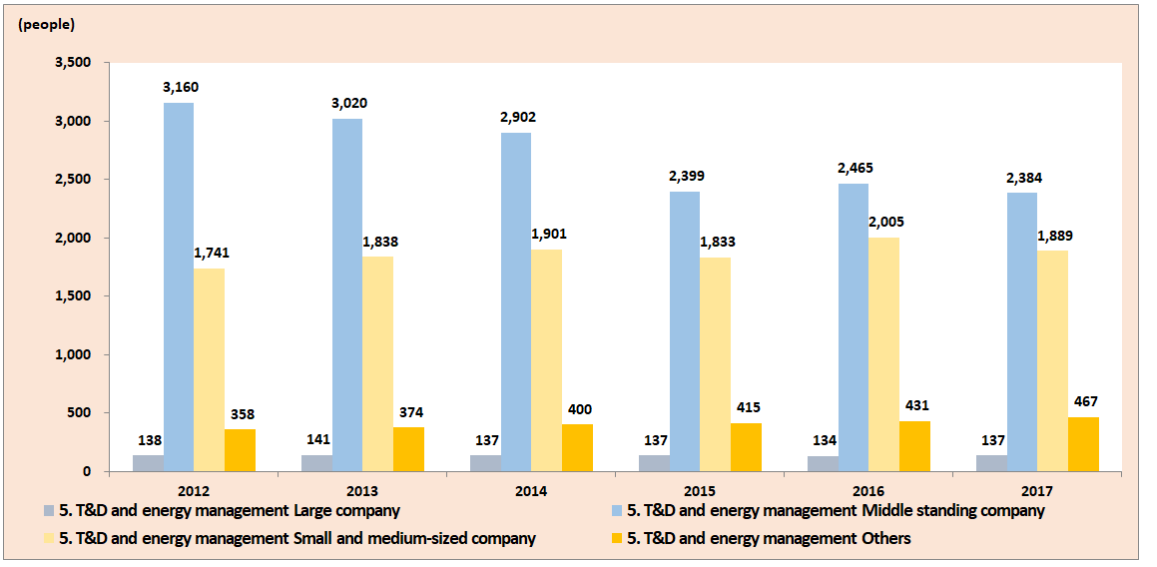
Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
4. Energy storage	Large company	23,578	24,547	26,230	26,043	25,607	26,165	25,362	2.10%
	Middle standing company	3,387	3,521	3,580	3,447	3,492	3,528	3,492	0.82%
	Small and medium-sized company	5,125	5,561	5,632	5,691	5,983	6,233	5,704	3.99%
	Others	38	41	48	62	66	75	55	14.66%
	Total	32,129	33,670	35,491	35,243	35,147	36,001	34,613	2.30%

5. The number of employees by business size in transmission and distribution and energy management technology related industry

- Between 2012 and 2017, the number of employees in transmission and distribution and energy management industry increased by -2.00%, indicating an overall decline.
- The number of employees in transmission and distribution and energy management sector over the past six years was estimated at an annual average of 5,134.
- The average annual growth rate in terms of business size was -0.09% for large companies, -5.48% for middle standing companies, 1.65% for small and medium companies and 5.45% for others.
- There are an annual average of 137 workers in large companies, 2,722 in middle standing companies, 1,868 in small and medium-sized companies, and 408 in others.



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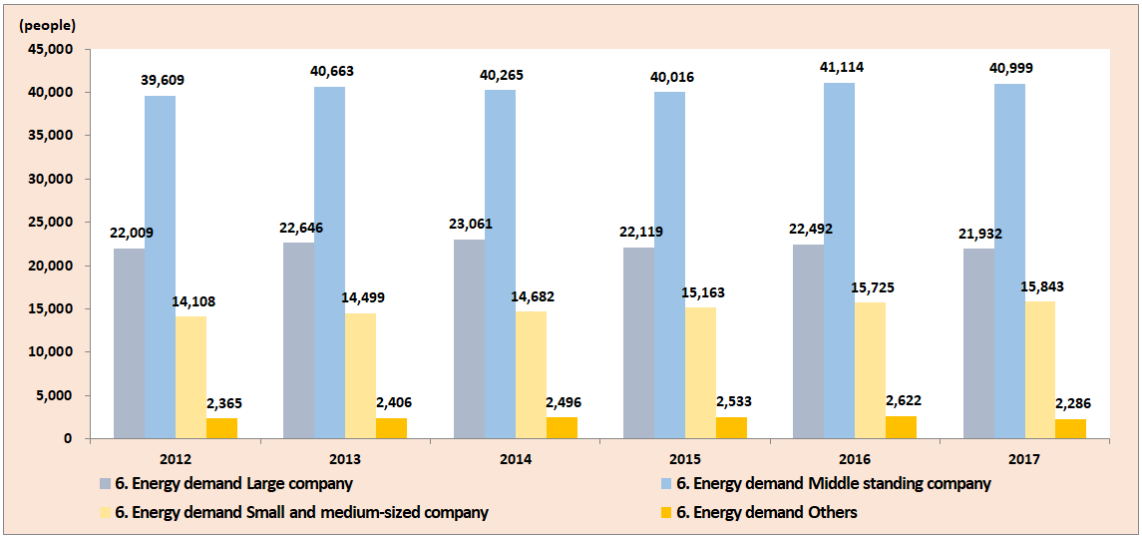
Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
5. Transmission and distribution and energy management	Large company	138	141	137	137	134	137	137	-0.09%
	Middle standing company	3,160	3,020	2,902	2,399	2,465	2,384	2,722	-5.48%
	Small and medium-sized company	1,741	1,838	1,901	1,833	2,005	1,889	1,868	1.65%
	Others	358	374	400	415	431	467	408	5.45%
	Total	5,397	5,373	5,340	4,783	5,035	4,878	5,134	-2.00%

6. The number of employees by business size in energy demand technology related industry

- Between 2012 and 2017, the number of employees in energy demand industry increased by 0.75%, indicating an overall rise.
- The number of employees in energy demand sector over the past six years was estimated at an annual average of 80,275.
- The average annual growth rate for large companies was -0.07% followed by 0.69% for middle standing companies, 2.35% for small and medium-sized companies and -0.68% for others, and all of them were on the rise except for large companies.
- There are an annual average of 22,376 workers in large companies, 40,444 in middle standing companies, 15,003 in small and medium-sized companies, and 2,451 in others.



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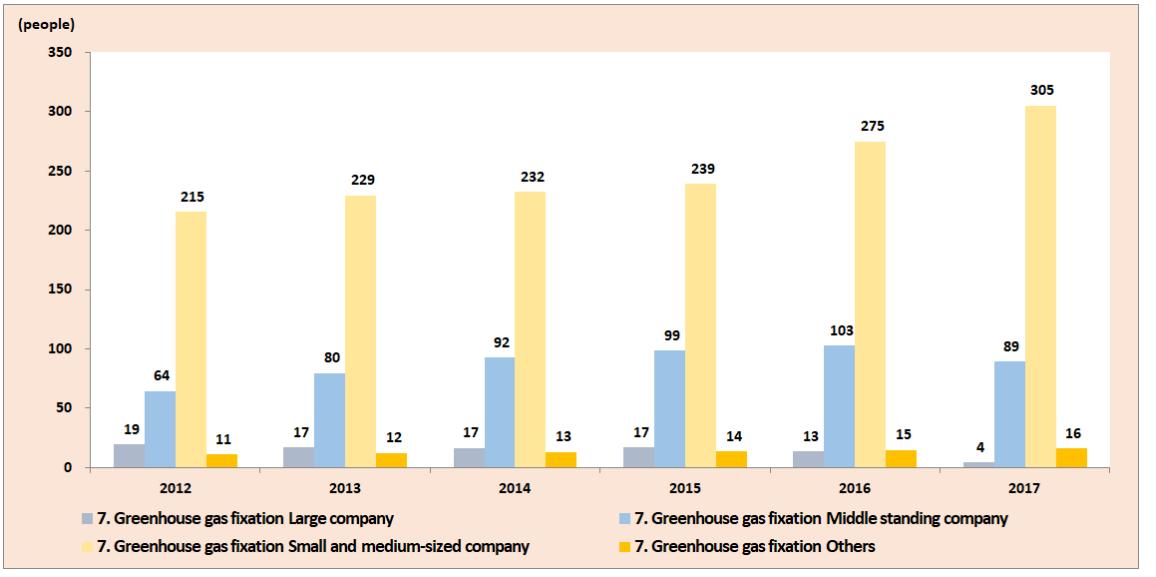
Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
6. Energy demand	Large company	22,009	22,646	23,061	22,119	22,492	21,932	22,376	-0.07%
	Middle standing company	39,609	40,663	40,265	40,016	41,114	40,999	40,444	0.69%
	Small and medium-sized company	14,108	14,499	14,682	15,163	15,725	15,843	15,003	2.35%
	Others	2,365	2,406	2,496	2,533	2,622	2,286	2,451	-0.68%
	Total	78,091	80,214	80,504	79,831	81,953	81,060	80,275	0.75%

7. The number of employees by business size in greenhouse gas fixation technology related industry

- Between 2012 and 2017, the number of employees in greenhouse gas fixation industry increased by 5.96%, indicating an overall rise.
- The number of employees in greenhouse gas fixation sector over the past six years was estimated at an annual average of 365.
- The average annual growth rate for large companies was -26.38% followed by 6.73% for middle standing companies, 7.21% for small and medium-sized companies and 7.39% for others, and all of them were on the rise except for large companies.
- There are an annual average of 15 workers in large companies, 88 in middle standing companies, 249 in small and medium-sized companies, and 13 in others.



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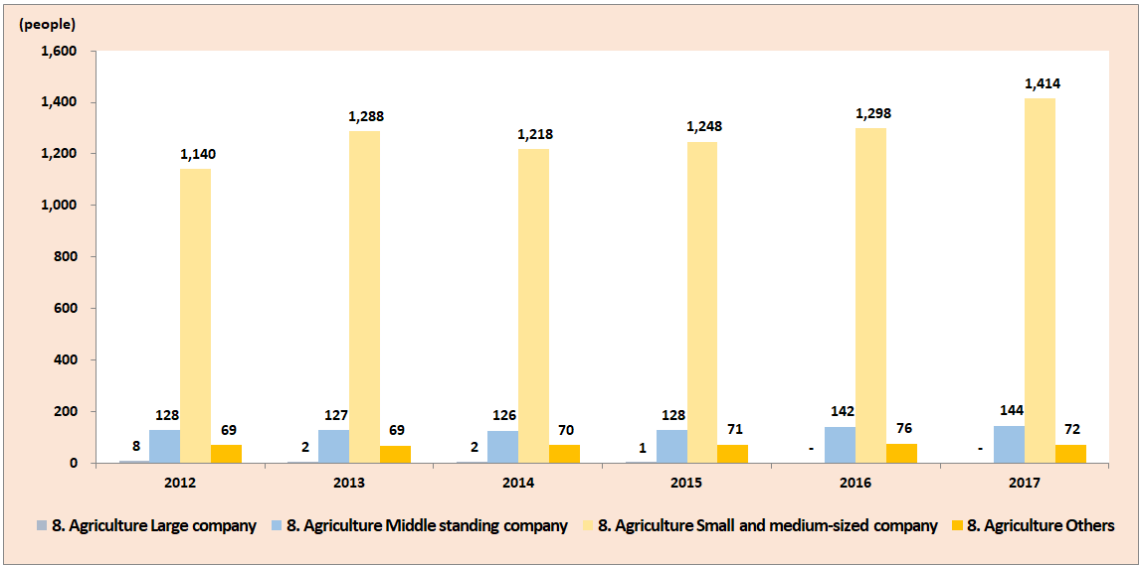
Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
7. Greenhouse gas fixation	Large company	19	17	17	17	13	4	15	-26.38%
	Middle standing company	64	80	92	99	103	89	88	6.73%
	Small and medium-sized company	215	229	232	239	275	305	249	7.21%
	Others	11	12	13	14	15	16	13	7.39%
	Total	310	338	355	368	406	415	365	5.96%

8. The number of employees by business size in agriculture and animal husbandry technology related industry

- Between 2012 and 2017, the number of employees in agriculture and animal husbandry industry increased by 3.91%, indicating an overall rise.
- The number of employees in agriculture and animal husbandry sector over the past six years was estimated at an annual average of 1,473.
- The average annual growth rate was -100.00% for large companies followed by 2.40% for middle standing companies, 4.40% for small and medium companies and 0.59% for others.
- There are an annual average of 2 workers in large companies, 132 in middle standing companies, 1,268 in small and medium-sized companies, and 71 in others.



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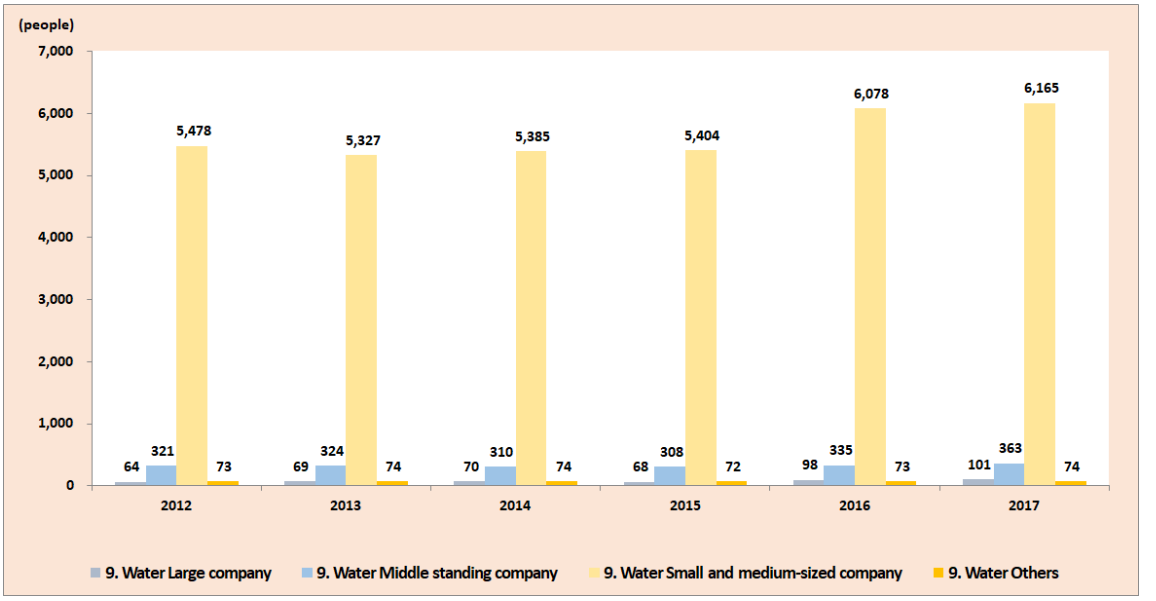
Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
8. Agriculture and animal husbandry	Large company	8	2	2	1	-	-	2	-100.00%
	Middle standing company	128	127	126	128	142	144	132	2.40%
	Small and medium-sized company	1,140	1,288	1,218	1,248	1,298	1,414	1,268	4.40%
	Others	69	69	70	71	76	72	71	0.59%
	Total	1,346	1,486	1,415	1,448	1,516	1,630	1,473	3.91%

9. The number of employees by business size in water technology related industry

- Between 2012 and 2017, the number of employees in water industry increased by 2.46%, indicating an overall rise.
- The number of employees in water sector over the past six years was estimated at an annual average of 6,118.
- The average annual growth rate for large companies was 9.63% followed by 2.50% for middle standing companies, 2.39% for small and medium-sized companies and 0.26% for others, and all of them were on the rise except for middle standing companies.
- There are an annual average of 78 workers in large companies, 327 in middle standing companies, 5,640 in small and medium-sized companies, and 73 in others.



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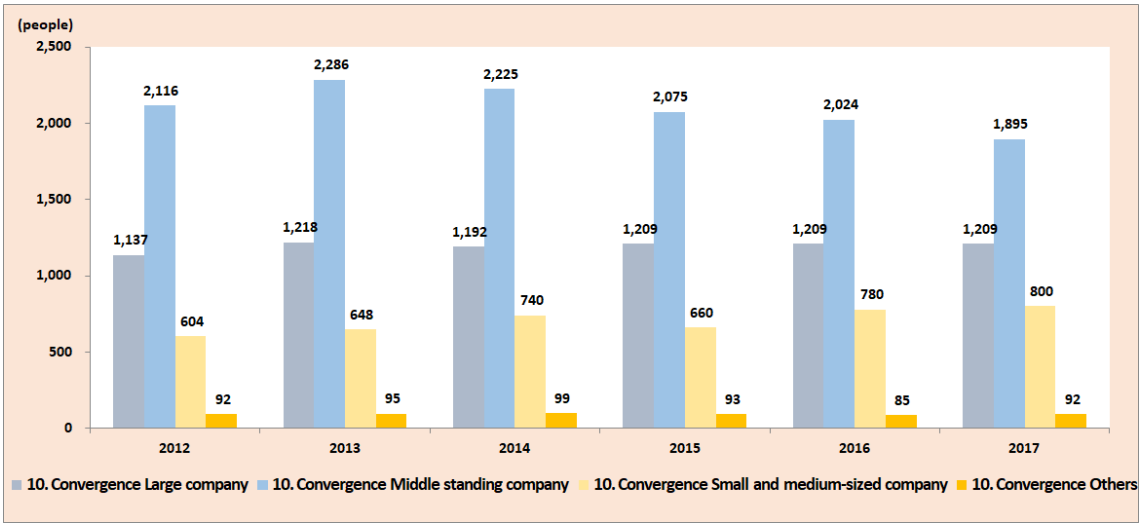
Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
9. Water	Large company	64	69	70	68	98	101	78	9.63%
	Middle standing company	321	324	310	308	335	363	327	2.50%
	Small and medium-sized company	5,478	5,327	5,385	5,404	6,078	6,165	5,640	2.39%
	Others	73	74	74	72	73	74	73	0.26%
	Total	5,936	5,794	5,839	5,853	6,584	6,703	6,118	2.46%

10. The number of employees by business size in Mitigation & Adaptation Convergence technology related industry

- Between 2012 and 2017, the number of employees in Mitigation & Adaptation Convergence industry increased by 0.24%, indicating an overall rise.
- The number of employees in Mitigation & Adaptation Convergence over the past six years was estimated at an annual average of 4,097.
- The average annual growth rate by business size was 1.23% for large companies followed by -2.18% for middle standing companies, 5.79% for small and medium companies and -0.15% for others.
- There are an annual average of 1,196 workers in large companies, 2,104 in middle standing companies, 705 in small and medium-sized companies, and 93 in others.



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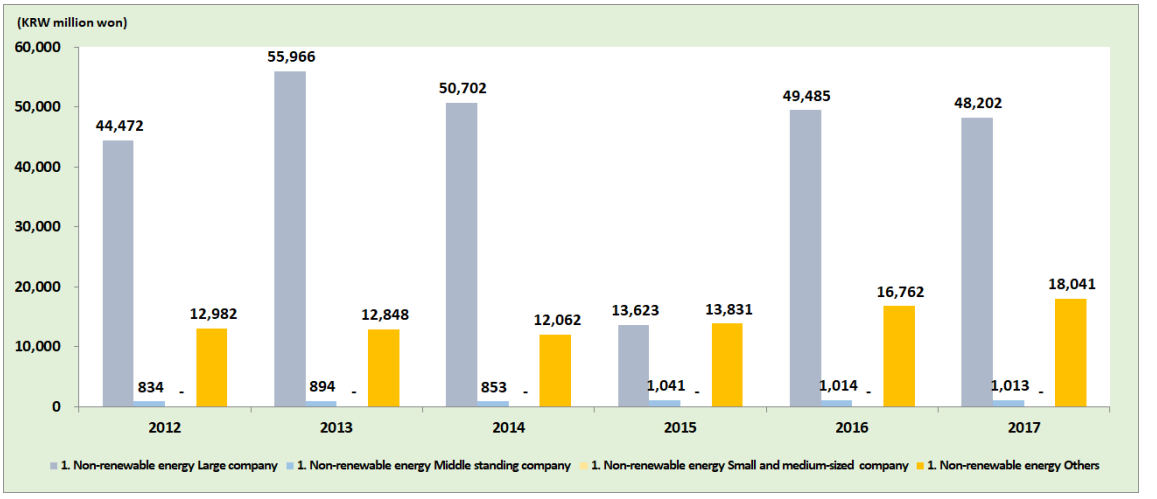
Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
10. Mitigation & Adaptation Convergence	Large company	1,137	1,218	1,192	1,209	1,209	1,209	1,196	1.23%
	Middle standing company	2,116	2,286	2,225	2,075	2,024	1,895	2,104	-2.18%
	Small and medium-sized company	604	648	740	660	780	800	705	5.79%
	Others	92	95	99	93	85	92	93	-0.15%
	Total	3,949	4,247	4,255	4,038	4,098	3,996	4,097	0.24%

Amount of R&D Expenses by Business Size in the Climate Technology from 2012 to 2017

1. Amount of R&D expenses by business size in non-renewable energy technology related industry

- From 2012 to 2017, the investment in non-renewable energy industry's R&D expenses has increased at an annual average growth rate of 2.90%.
- Over the past six years, an annual average of 59 billion won has been invested in R&D expenses in non-renewable energy sector.
- The average annual growth rate was 1.62% for large companies, 3.97% for middle standing companies and 6.80% for others, indicating an overall rise.
- In the case of large companies, the average annual investment is 43 billion won, while middle standing companies and others were invested with 0.9 billion won and 14 billion won, respectively.

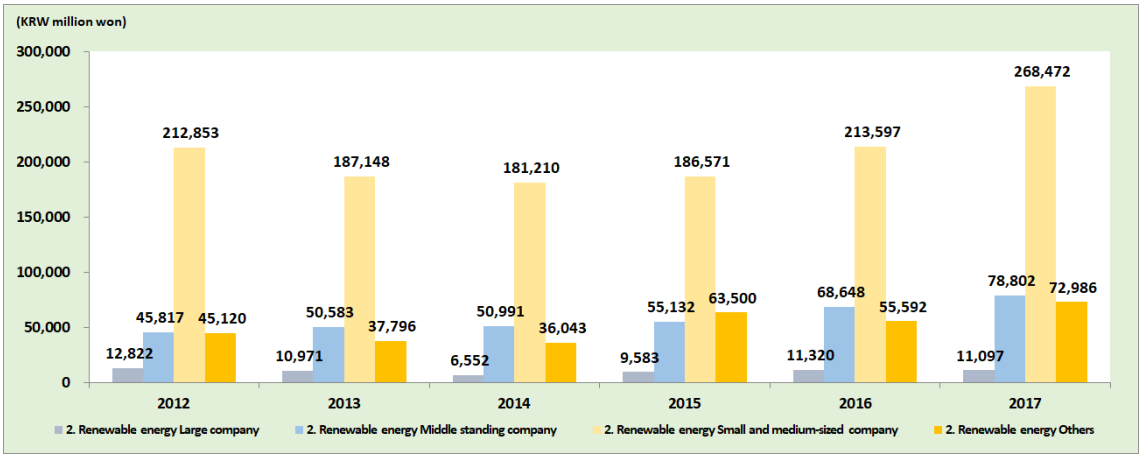


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
1. Non-renewable energy	Large company	44,472	55,966	50,702	13,623	49,485	48,202	43,742	1.62%
	Middle standing company	834	894	853	1,041	1,014	1,013	942	3.97%
	Small and medium-sized company	-	-	-	-	-	-	-	-
	Others	12,982	12,848	12,062	13,831	16,762	18,041	14,421	6.80%
	Total	58,288	69,708	63,617	28,495	67,261	67,256	59,104	2.90%

2. Amount of R&D expenses by business size in renewable energy technology related industry

- From 2012 to 2017, the investment in renewable energy industry's R&D expenses has increased at an annual average growth rate of 6.38%.
- Over the past six years, an annual average of 328 billion won has been invested in R&D expenses in renewable energy sector.
- The average annual growth rate for large companies was -2.85% followed by 11.46% for middle standing companies, 4.75% for small and medium-sized companies and 10.10% for others, and all of them were on the rise except for large companies.
- In the case of large companies, the average annual investment is 10 billion won, while middle standing companies, small and medium-sized companies, and others are invested with 58 billion won, 208 billion won. and 51 billion won, respectively.

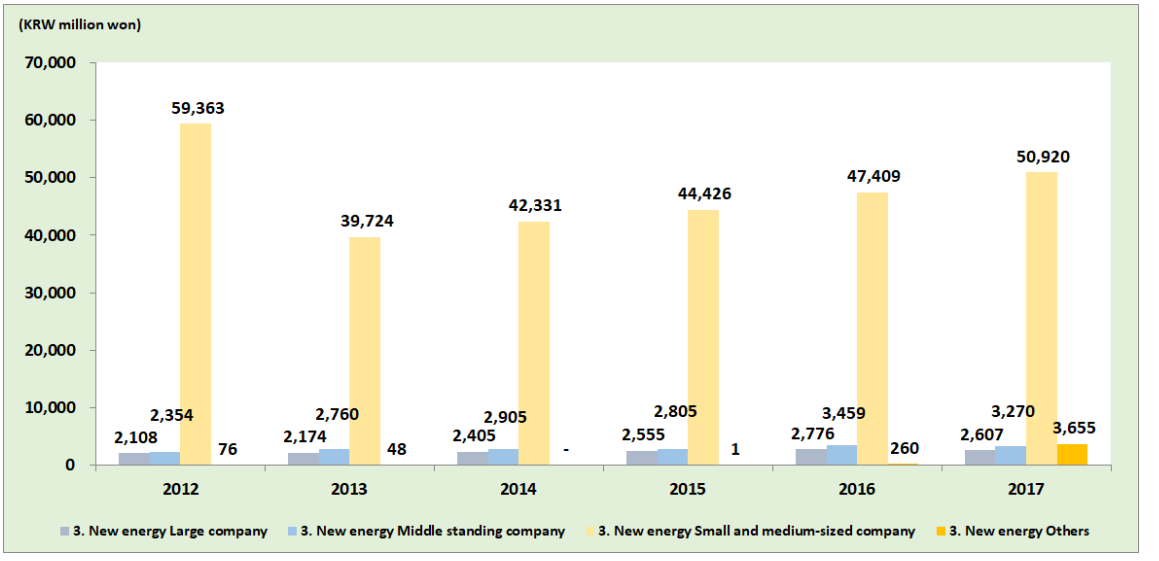


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
2. Renewable energy	Large company	12,822	10,971	6,552	9,583	11,320	11,097	10,391	-2.85%
	Middle standing company	45,817	50,583	50,991	55,132	68,648	78,802	58,329	11.46%
	Small and medium-sized company	212,853	187,148	181,210	186,571	213,597	268,472	208,309	4.75%
	Others	45,120	37,796	36,043	63,500	55,592	72,986	51,839	10.10%
	Total	316,611	286,497	274,796	314,786	349,158	431,357	328,868	6.38%

3. Amount of R&D expenses by business size in new energy technology related industry

- From 2012 to 2017, the investment in new energy industry's R&D expenses has increased at an annual average growth rate of -1.10%.
- Over the past six years, an annual average of 53 billion won has been invested in R&D expenses in new energy sector.
- The average annual growth rate for large companies was 4.34% followed by 6.79% for middle standing companies, and -3.02% for small and medium-sized companies.
- In the case of large companies, the average annual investment is 2 billion won, while middle standing companies and small and medium-sized companies are invested with 2 billion won and 47 billion won, respectively.

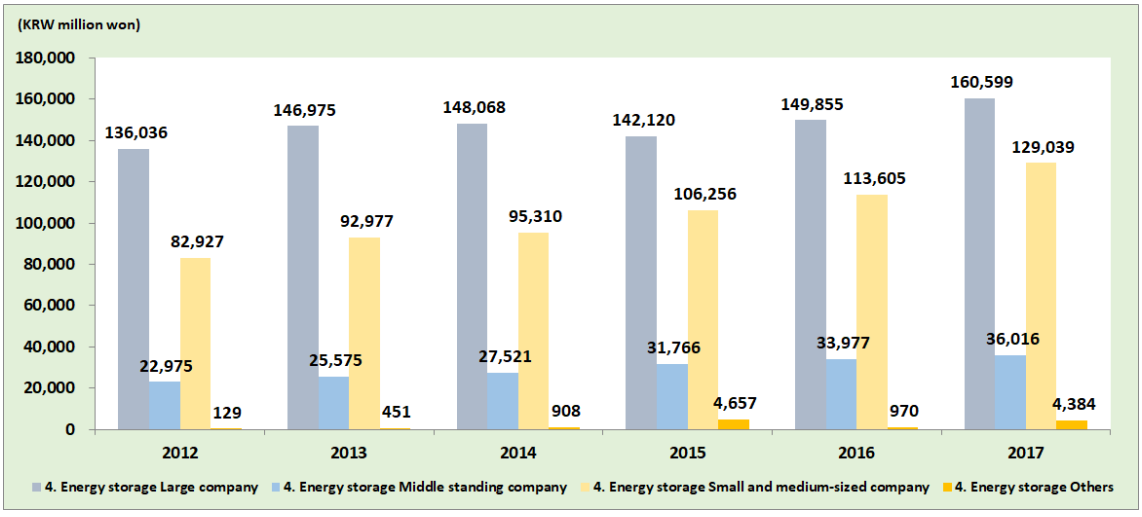


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
3. New energy	Large company	2,108	2,174	2,405	2,555	2,776	2,607	2,438	4.34%
	Middle standing company	2,354	2,760	2,905	2,805	3,459	3,270	2,926	6.79%
	Small and medium-sized company	59,363	39,724	42,331	44,426	47,409	50,920	47,362	-3.02%
	Others	76	48	-	1	260	3,655	673	116.71%
	Total	63,901	44,706	47,642	49,787	53,904	60,452	53,399	-1.10%

4. Amount of R&D expenses by business size in energy storage technology related industry

- From 2012 to 2017, the investment in energy storage industry's R&D expenses has increased at an annual average growth rate of 6.40%.
- Over the past six years, an annual average of 282 billion won has been invested in R&D expenses in energy storage sector.
- The average annual growth rate of large companies, middle standing companies, small and medium-sized companies, and others is all on the rise by 3.38%, 9.41%, 9.25%, and 102.42%, respectively.
- In the case of large companies, the average annual investment is 147 billion won, while middle standing companies, small and medium-sized companies, and others are invested with is 29 billion won, 103 billion won, and 1 billion won, respectively.

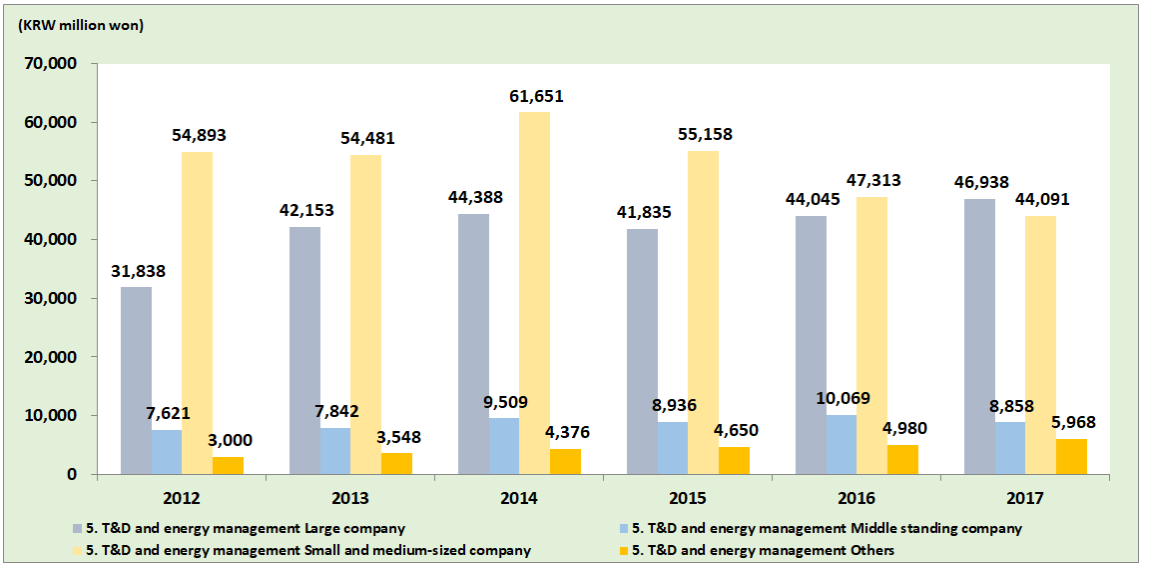


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
4. Energy storage	Large company	136,036	146,975	148,068	142,120	149,855	160,599	147,276	3.38%
	Middle standing company	22,975	25,575	27,521	31,766	33,977	36,016	29,639	9.41%
	Small and medium-sized company	82,927	92,977	95,310	106,256	113,605	129,039	103,352	9.25%
	Others	129	451	908	4,657	970	4,384	1,917	102.42%
	Total	242,067	265,978	271,808	284,800	298,408	330,039	282,183	6.40%

5. Amount of R&D expenses by business size in transmission and distribution and energy management technology related industry

- From 2012 to 2017, the investment in transmission and distribution and energy management industry's R&D expenses has increased at an annual average growth rate of 1.69%.
- Over the past six years, an annual average of 108 billion won has been invested in R&D expenses in Transmission and distribution and energy management sector.
- The average annual growth rate of large companies, middle standing companies, small and medium-sized companies, and others are all on the rise by 8.07%, 3.05%, -4.29%, and 14.75%, respectively.
- In the case of large companies, the average annual investment is 41 billion won, while middle standing companies, small and medium-sized companies, and others are invested with 8 billion won, 52 billion won, and 4 billion won, respectively.

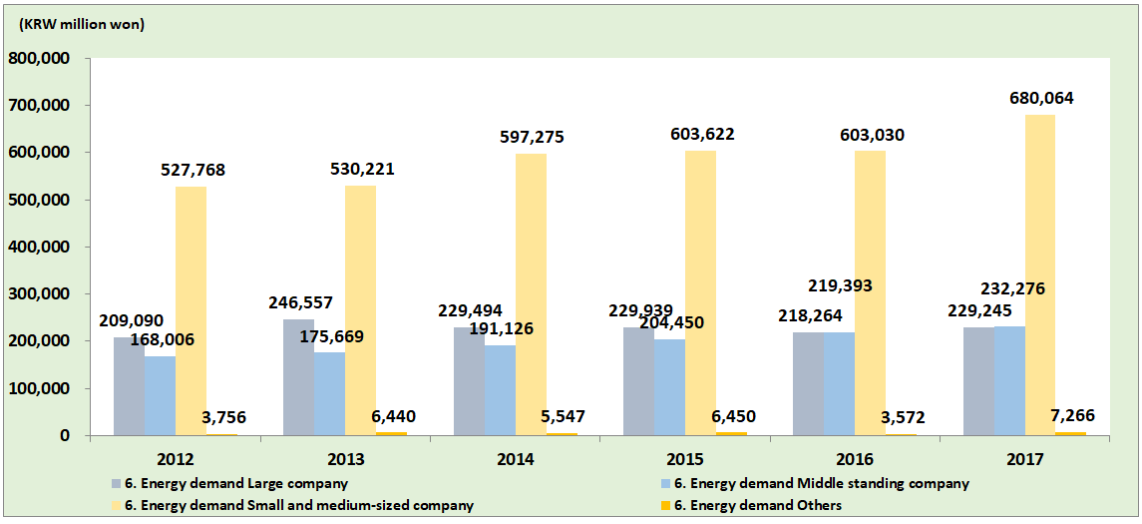


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
5. Transmission and distribution and energy management	Large company	31,838	42,153	44,388	41,835	44,045	46,938	41,866	8.07%
	Middle standing company	7,621	7,842	9,509	8,936	10,069	8,858	8,806	3.05%
	Small and medium-sized company	54,893	54,481	61,651	55,158	47,313	44,091	52,931	-4.29%
	Others	3,000	3,548	4,376	4,650	4,980	5,968	4,420	14.75%
	Total	97,351	108,024	119,925	110,579	106,407	105,855	108,024	1.69%

6. Amount of R&D expenses by business size in energy demand technology related industry

- From 2012 to 2017, the investment in energy demand industry's R&D expenses has increased at an annual average growth rate of 4.80%.
- Over the past six years, an annual average of 1,021 billion won has been invested in R&D expenses in energy demand sector.
- The average annual growth rate for large companies was 1.86% followed by 6.69% for middle standing companies, 5.20% for small and medium-sized companies and 14.11% for others, and all of them were on the rise except for non-profit organizations such as other research institutes.
- In the case of large companies, the average annual investment is 227 billion won, while middle standing companies, small and medium-sized companies, and others are invested with 198 billion won, 590 billion won. and 5 billion won, respectively.

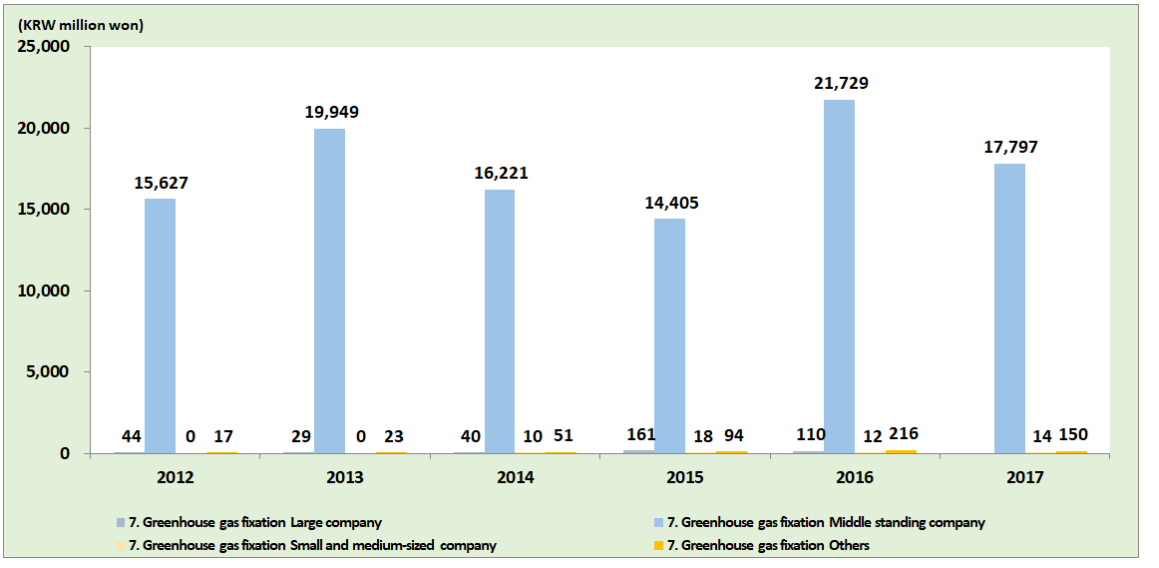


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
6. Energy demand	Large company	209,090	246,557	229,494	229,939	218,264	229,245	227,098	1.86%
	Middle standing company	168,006	175,669	191,126	204,450	219,393	232,276	198,486	6.69%
	Small and medium-sized company	527,768	530,221	597,275	603,622	603,030	680,064	590,330	5.20%
	Others	3,756	6,440	5,547	6,450	3,572	7,266	5,505	14.11%
	Total	908,619	958,887	1,023,441	1,044,460	1,044,259	1,148,851	1,021,420	4.80%

7. Amount of R&D expenses by business size in greenhouse gas fixation technology related industry

- From 2012 to 2017, the investment in greenhouse gas fixation industry's R&D expenses has decreased at an annual average growth rate of 2.74%.
- Over the past six years, an annual average of 17 billion won has been invested in R&D expenses in greenhouse gas fixation sector.
- The average annual growth rate for large companies was -167.13%, 2.63% for middle standing companies, 12.73% for small and medium-sized companies and followed by 54.57% for others.
- In the case of large companies, the average annual investment is 63 million won, while middle standing companies, small and medium-sized companies, and others are invested with 17 billion won, 9 million won, 92 million won, respectively.

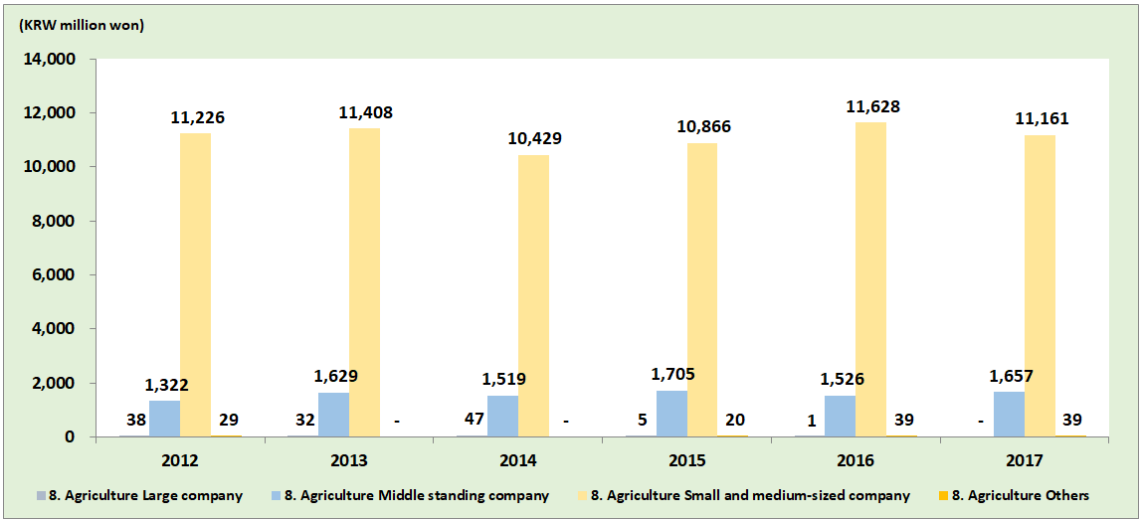


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
7. Greenhouse gas fixation	Large company	44	29	40	161	110	-6	63	-167.13%
	Middle standing company	15,627	19,949	16,221	14,405	21,729	17,797	17,621	2.63%
	Small and medium-sized company	-	-	10	18	12	14	9	12.73%
	Others	17	23	51	94	216	150	92	54.57%
	Total	15,688	20,001	16,322	14,678	22,067	17,955	17,785	2.74%

8. Amount of R&D expenses by business size in agriculture and animal husbandry technology related industry

- From 2012 to 2017, the investment in agriculture and animal husbandry industry's R&D expenses has increased at an annual average growth rate of 0.38%.
- Over the past six years, an annual average of 12 billion won has been invested in R&D expenses in agriculture and animal husbandry sector.
- The average annual growth rate for middle standing companies was 4.63%, -0.12% for small and medium-sized companies, and 6.09% for others.
- In the case of large companies, the average annual investment is 21 million won, while middle standing companies, small and medium-companies, and others are invested with 1 billion won, 11 billion won, and 21 million won, respectively.

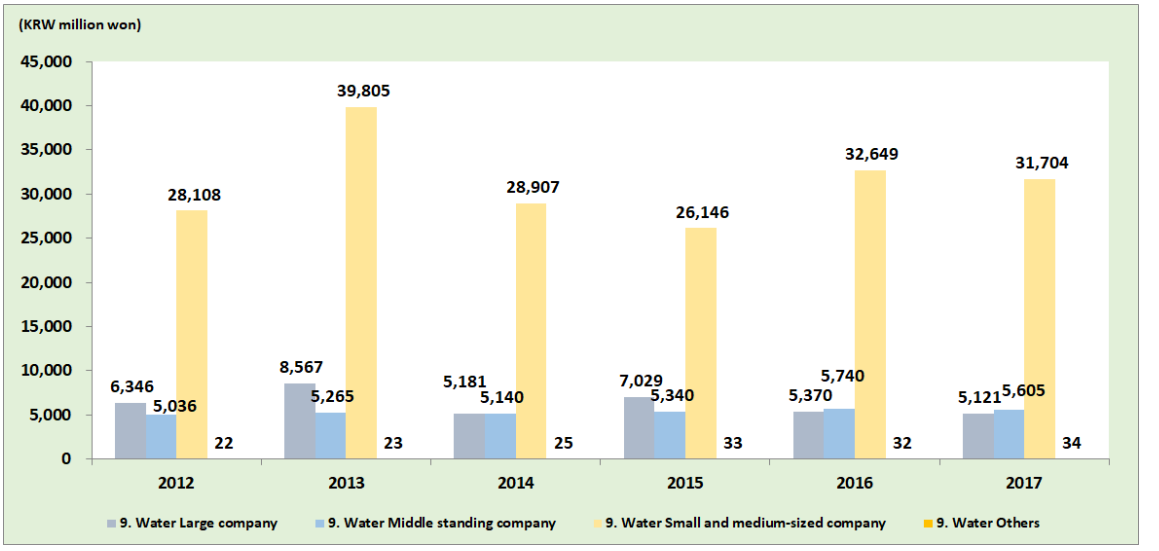


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
8. Agriculture and animal husbandry	Large company	38	32	47	5	1	-	21	-100.00%
	Middle standing company	1,322	1,629	1,519	1,705	1,526	1,657	1,560	4.63%
	Small and medium-sized company	11,226	11,408	10,429	10,866	11,628	11,161	11,120	-0.12%
	Others	29	-	-	20	39	39	21	6.09%
	Total	12,615	13,069	11,996	12,596	13,194	12,858	12,721	0.38%

9. Amount of R&D expenses by business size in water technology related industry

- From 2012 to 2017, the investment in water industry's R&D expenses has increased at an annual average growth rate of 1.45%.
- Over the past six years, an annual average of 42 billion won has been invested in R&D expenses in water sector.
- The average annual growth rate for large companies was -4.20% followed by 2.17% for middle standing companies, 2.44% for small and medium-sized companies and 9.19% for others, all of which were on the increase except for large companies.
- In the case of large companies, the average annual investment is 6 billion won, while middle standing companies, small and medium-companies, and others are invested with 5 billion won, 31 billion won, and 28 million won, respectively.

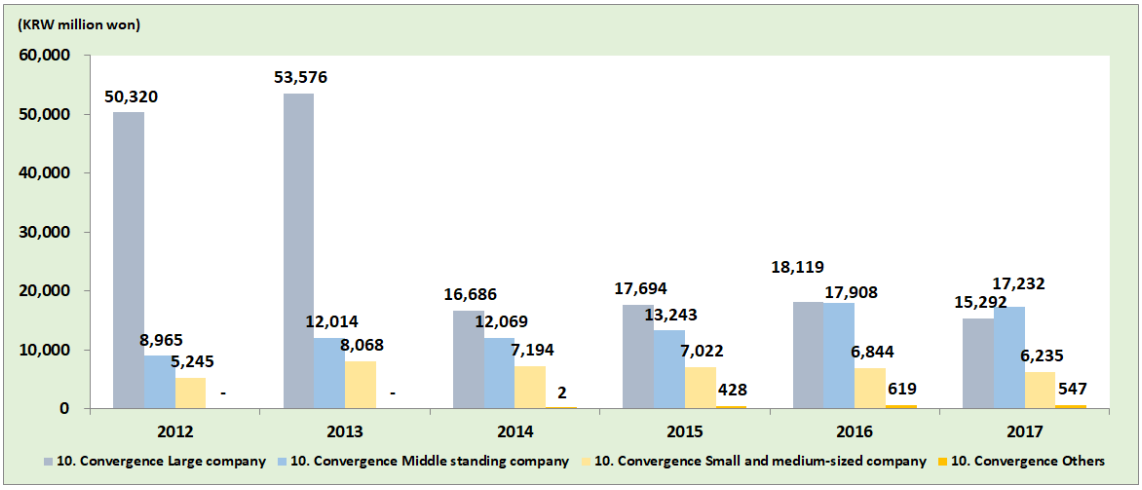


(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
9. Water	Large company	6,346	8,567	5,181	7,029	5,370	5,121	6,269	-4.20%
	Middle standing company	5,036	5,265	5,140	5,340	5,740	5,605	5,354	2.17%
	Small and medium-sized company	28,108	39,805	28,907	26,146	32,649	31,704	31,220	2.44%
	Others	22	23	25	33	32	34	28	9.19%
	Total	39,512	53,660	39,252	38,549	43,791	42,464	42,871	1.45%

10. Amount of R&D expenses by business size in mitigation & adaptation convergence technology related industry

- From 2012 to 2017, the investment in Mitigation & Adaptation Convergence industry's R&D expenses has decreased at an annual average growth rate of -9.44%.
- Over the past six years, an annual average of 49 billion won has been invested in R&D expenses in mitigation & adaptation convergence sector.
- The average annual growth rate for large companies was -21.20% followed by 13.96% for middle standing companies, and 3.52% for small and medium-sized companies.
- In the case of large companies, the average annual investment is 28 billion won, while middle standing companies, small and medium-companies, and others are invested with 13 billion won, 6 billion won, and 266 million won, respectively.



(unit: KRW million won)

Division	Business size	2012	2013	2014	2015	2016	2017	Average	Annual growth rate
10. Mitigation & Adaptation Convergence	Large company	50,320	53,576	16,686	17,694	18,119	15,292	28,615	-21.20%
	Middle standing company	8,965	12,014	12,069	13,243	17,908	17,232	13,572	13.96%
	Small and medium-sized company	5,245	8,068	7,194	7,022	6,844	6,235	6,768	3.52%
	Others	-	-	2	428	619	547	266	549.11%
	Total	64,530	73,658	35,951	38,387	43,491	39,306	49,220	-9.44%

3.4.2.6. Summaries of the Climate Technology Industry

▶ Amount of Sales by Division and Business Size in Climate Technology from 2012 to 2017

(unit: KRW million won)

Class	Division	2012									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)
Total		171,620,677	100.0%	106,657,916	100.0%	48,287,773	100.0%	16,674,988	100.0%	-	0%
Mitigation	Subtotal	157,460,147	91.7%	98,407,543	92.3%	44,122,525	91.4%	14,930,079	89.5%	-	0%
	1. Non-renewable energy	1,027,501	0.6%	628,469	0.6%	46,667	0.1%	352,365	2.1%	-	0%
	2. Renewable energy	35,086,961	20.4%	22,294,879	20.9%	7,179,468	14.9%	5,612,614	33.7%	-	0%
	3. New energy	13,354,066	7.8%	11,030,136	10.3%	1,986,745	4.1%	337,185	2.0%	-	0%
	4. Energy storage	37,150,940	21.6%	26,967,172	25.3%	8,440,870	17.5%	1,742,898	10.5%	-	0%
	5. Transmission and distribution and energy management	8,709,826	5.1%	3,054,486	2.9%	5,113,915	10.6%	541,425	3.2%	-	0%
	6. Energy demand	56,422,506	32.9%	28,826,571	27.0%	21,323,776	44.2%	6,272,159	37.6%	-	0%
	7. Greenhouse gas fixation	5,708,347	3.3%	5,605,830	5.3%	31,083	0.1%	71,434	0.4%	-	0%
Adaptation	Subtotal	9,144,645	5.3%	7,423,219	7.0%	468,212	1.0%	1,253,215	7.5%	-	0%
	8. Agriculture and animal husbandry	337,331	0.2%	3	0.0%	43,434	0.1%	293,894	1.8%	-	0%
	9. Water	8,807,314	5.1%	7,423,216	7.0%	424,778	0.9%	959,321	5.8%	-	0%
Mitigation & Adaptation Convergence	Subtotal	5,015,886	2.9%	827,155	0.8%	3,697,036	7.7%	491,695	2.9%	-	0%
	10. Mitigation & Adaptation Convergence	5,015,886	2.9%	827,155	0.8%	3,697,036	7.7%	491,695	2.9%	-	0%

(unit: KRW million won)

Class	Division	2013									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)
Total		167,827,935	100.0%	104,108,971	100.0%	46,611,655	100.0%	17,107,309	100.0%	0	0%
Mitigation	Subtotal	154,171,751	91.9%	95,702,904	91.9%	43,160,320	92.6%	15,308,528	89.5%	0	0%
	1. Non-renewable energy	964,377	0.6%	604,387	0.6%	36,864	0.1%	323,126	1.9%	0	0%
	2. Renewable energy	34,098,156	20.3%	21,580,793	20.7%	6,925,488	14.9%	5,591,875	32.7%	0	0%
	3. New energy	12,910,625	7.7%	11,066,473	10.6%	1,438,815	3.1%	405,337	2.4%	0	0%
	4. Energy storage	36,124,920	21.5%	26,013,867	25.0%	8,288,193	17.8%	1,822,860	10.7%	0	0%
	5. Transmission and distribution and energy management	8,998,320	5.4%	3,301,261	3.2%	5,106,982	11.0%	590,076	3.4%	0	0%
	6. Energy demand	56,008,935	33.4%	28,245,596	27.1%	21,314,968	45.7%	6,448,371	37.7%	0	0%
	7. Greenhouse gas fixation	5,066,419	3.0%	4,890,526	4.7%	49,010	0.1%	126,883	0.7%	0	0%
Adaptation	Subtotal	9,162,623	5.5%	7,496,556	7.2%	410,827	0.9%	1,255,240	7.3%	0	0%
	8. Agriculture and animal husbandry	361,661	0.2%	3	0.0%	43,246	0.1%	318,412	1.9%	0	0%
	9. Water	8,800,962	5.2%	7,496,553	7.2%	367,581	0.8%	936,828	5.5%	0	0%
Mitigation & Adaptation Convergence	Subtotal	4,493,561	2.7%	909,512	0.9%	3,040,508	6.5%	543,541	3.2%	0	0%
	10. Mitigation & Adaptation Convergence	4,493,561	2.7%	909,512	0.9%	3,040,508	6.5%	543,541	3.2%	0	0%

(unit: KRW million won)

Class	Division	2014									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)
Total		163,626,749	100.0%	101,333,626	100.0%	44,839,224	100.0%	17,453,898	100.0%	0	0%
Mitigation	Subtotal	150,388,780	91.9%	93,158,934	91.9%	41,595,586	92.8%	15,634,260	89.6%	0	0%
	1. Non-renewable energy	1,005,335	0.6%	673,534	0.7%	22,709	0.1%	309,092	1.8%	0	0%
	2. Renewable energy	33,248,773	20.3%	20,872,400	20.6%	6,626,573	14.8%	5,749,801	32.9%	0	0%
	3. New energy	10,930,300	6.7%	9,105,627	9.0%	1,435,534	3.2%	389,139	2.2%	0	0%
	4. Energy storage	36,052,539	22.0%	26,278,778	25.9%	7,929,782	17.7%	1,843,978	10.6%	0	0%
	5. Transmission and distribution and energy management	8,251,464	5.0%	3,046,087	3.0%	4,540,109	10.1%	665,267	3.8%	0	0%
	6. Energy demand	55,785,782	34.1%	28,261,799	27.9%	20,968,412	46.8%	6,555,571	37.6%	0	0%
	7. Greenhouse gas fixation	5,114,587	3.1%	4,920,709	4.9%	72,467	0.2%	121,411	0.7%	0	0%
Adaptation	Subtotal	8,794,060	5.4%	7,192,742	7.1%	373,838	0.8%	1,227,480	7.0%	0	0%
	8. Agriculture and animal husbandry	359,290	0.2%	2	0.0%	43,008	0.1%	316,280	1.8%	0	0%
	9. Water	8,434,770	5.2%	7,192,740	7.1%	330,830	0.7%	911,200	5.2%	0	0%
Mitigation & Adaptation Convergence	Subtotal	4,443,908	2.7%	981,950	1.0%	2,869,801	6.4%	592,157	3.4%	0	0%
	10. Mitigation & Adaptation Convergence	4,443,908	2.7%	981,950	1.0%	2,869,801	6.4%	592,157	3.4%	0	0%

(unit: KRW million won)

Class	Division	2015									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)
Total		156,378,131	100.0%	94,077,423	100.0%	44,241,910	100.0%	18,058,798	100.0%	0	0%
Mitigation	Subtotal	143,846,895	92.0%	86,735,370	92.2%	40,929,202	92.5%	16,182,323	89.6%	0	0%
	1. Non-renewable energy	888,984	0.6%	526,082	0.6%	22,293	0.1%	340,609	1.9%	0	0%
	2. Renewable energy	34,455,845	22.0%	21,639,829	23.0%	6,945,731	15.7%	5,870,285	32.5%	0	0%
	3. New energy	8,227,751	5.3%	6,515,162	6.9%	1,347,493	3.0%	365,097	2.0%	0	0%
	4. Energy storage	33,822,582	21.6%	24,418,237	26.0%	7,463,935	16.9%	1,940,409	10.7%	0	0%
	5. Transmission and distribution and energy management	7,542,396	4.8%	3,042,052	3.2%	3,836,064	8.7%	664,280	3.7%	0	0%
	6. Energy demand	55,160,960	35.3%	27,034,582	28.7%	21,250,666	48.0%	6,875,712	38.1%	0	0%
	7. Greenhouse gas fixation	3,748,375	2.4%	3,559,426	3.8%	63,020	0.1%	125,929	0.7%	0	0%
Adaptation	Subtotal	8,001,183	5.1%	6,399,773	6.8%	348,929	0.8%	1,252,481	6.9%	0	0%
	8. Agriculture and animal husbandry	355,834	0.2%	3	0.0%	44,188	0.1%	311,643	1.7%	0	0%
	9. Water	7,645,348	4.9%	6,399,770	6.8%	304,741	0.7%	940,838	5.2%	0	0%
Mitigation & Adaptation Convergence	Subtotal	4,530,053	2.9%	942,280	1.0%	2,963,779	6.7%	623,994	3.5%	0	0%
	10. Mitigation & Adaptation Convergence	4,530,053	2.9%	942,280	1.0%	2,963,779	6.7%	623,994	3.5%	0	0%

(unit: KRW million won)

Class	Division	2016									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)
Total		159,556,972	100.0%	96,142,879	100.0%	44,334,806	100.0%	19,079,287	100.0%	0	0%
Mitigation	Subtotal	147,011,381	92.1%	88,627,945	92.2%	41,208,015	92.9%	17,175,421	90.0%	0	0%
	1. Non-renewable energy	799,674	0.5%	404,810	0.4%	24,671	0.1%	370,193	1.9%	0	0%
	2. Renewable energy	39,142,812	24.5%	25,626,224	26.7%	7,215,056	16.3%	6,301,532	33.0%	0	0%
	3. New energy	7,489,457	4.7%	5,895,165	6.1%	1,214,948	2.7%	379,345	2.0%	0	0%
	4. Energy storage	33,924,487	21.3%	24,327,220	25.3%	7,491,344	16.9%	2,105,922	11.0%	0	0%
	5. Transmission and distribution and energy management	7,265,845	4.6%	3,022,880	3.1%	3,557,870	8.0%	685,095	3.6%	0	0%
	6. Energy demand	54,089,323	33.9%	25,281,626	26.3%	21,632,462	48.8%	7,175,235	37.6%	0	0%
	7. Greenhouse gas fixation	4,299,783	2.7%	4,070,020	4.2%	71,665	0.2%	158,098	0.8%	0	0%
Adaptation	Subtotal	8,142,253	5.1%	6,542,637	6.8%	342,990	0.8%	1,256,626	6.6%	0	0%
	8. Agriculture and animal husbandry	363,140	0.2%	1	0.0%	47,837	0.1%	315,302	1.7%	0	0%
	9. Water	7,779,113	4.9%	6,542,636	6.8%	295,153	0.7%	941,324	4.9%	0	0%
Mitigation & Adaptation Convergence	Subtotal	4,403,338	2.8%	972,297	1.0%	2,783,801	6.3%	647,240	3.4%	0	0%
	10. Mitigation & Adaptation Convergence	4,403,338	2.8%	972,297	1.0%	2,783,801	6.3%	647,240	3.4%	0	0%

(unit: KRW million won)

Class	Division	2017									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)	Sales	Share (%)
Total		171,382,539	100.0%	104,736,702	100.0%	45,671,047	100.0%	20,974,791	100.0%	0	0%
Mitigation	Subtotal	158,543,795	92.5%	96,894,496	92.5%	42,666,705	93.4%	18,982,594	90.5%	0	0%
	1. Non-renewable energy	815,255	0.5%	392,154	0.4%	30,891	0.1%	392,210	1.9%	0	0%
	2. Renewable energy	40,708,189	23.8%	26,035,911	24.9%	7,450,815	16.3%	7,221,464	34.4%	0	0%
	3. New energy	8,669,091	5.1%	7,057,984	6.7%	1,199,601	2.6%	411,506	2.0%	0	0%
	4. Energy storage	40,220,181	23.5%	29,425,821	28.1%	8,425,055	18.4%	2,369,305	11.3%	0	0%
	5. Transmission and distribution and energy management	8,158,643	4.8%	3,614,652	3.5%	3,858,102	8.4%	685,889	3.3%	0	0%
	6. Energy demand	55,792,657	32.6%	26,470,654	25.3%	21,634,383	47.4%	7,687,621	36.7%	0	0%
	7. Greenhouse gas fixation	4,179,779	2.4%	3,897,321	3.7%	67,859	0.1%	214,599	1.0%	0	0%
Adaptation	Subtotal	8,472,677	4.9%	6,769,533	6.5%	396,201	0.9%	1,306,943	6.2%	0	0%
	8. Agriculture and animal husbandry	389,878	0.2%	-	0.0%	50,489	0.1%	339,389	1.6%	0	0%
	9. Water	8,082,799	4.7%	6,769,533	6.5%	345,711	0.8%	967,554	4.6%	0	0%
Mitigation & Adaptation Convergence	Subtotal	4,366,067	2.5%	1,072,672	1.0%	2,608,141	5.7%	685,254	3.3%	0	0%
	10. Mitigation & Adaptation Convergence	4,366,067	2.5%	1,072,672	1.0%	2,608,141	5.7%	685,254	3.3%	0	0%

Amount of R&D Expenses in Climate Technology Industries from 2012 to 2017

(unit: KRW million won)

Class	Division	2012									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)
Total		1,819,184	100.0%	493,113	100.0%	278,556	100.0%	982,383	100.0%	65,131	100.0%
Mitigation	Subtotal	1,702,527	93.6%	436,409	88.5%	263,234	94.5%	937,803	95.5%	65,080	99.9%
	1. Non-renewable energy	58,288	3.2%	44,472	9.0%	834	0.3%	-	0.0%	12,982	19.9%
	2. Renewable energy	316,611	17.4%	12,822	2.6%	45,817	16.4%	212,853	21.7%	45,120	69.3%
	3. New energy	63,901	3.5%	2,108	0.4%	2,354	0.8%	59,363	6.0%	76	0.1%
	4. Energy storage	242,067	13.3%	136,036	27.6%	22,975	8.2%	82,927	8.4%	129	0.2%
	5. Transmission and distribution and energy management	97,351	5.4%	31,838	6.5%	7,621	2.7%	54,893	5.6%	3,000	4.6%
	6. Energy demand	908,619	49.9%	209,090	42.4%	168,006	60.3%	527,768	53.7%	3,756	5.8%
	7. Greenhouse gas fixation	15,688	0.9%	44	0.0%	15,627	5.6%	-	0.0%	17	0.0%
Adaptation	Subtotal	52,127	2.9%	6,384	1.3%	6,357	2.3%	39,335	4.0%	51	0.1%
	8. Agriculture and animal husbandry	12,615	0.7%	38	0.0%	1,322	0.5%	11,226	1.1%	29	0.0%
	9. Water	39,512	2.2%	6,346	1.3%	5,036	1.8%	28,108	2.9%	22	0.0%
Mitigation & Adaptation Convergence	Subtotal	64,530	3.5%	50,320	10.2%	8,965	3.2%	5,245	0.5%	-	0.0%
	10. Mitigation & Adaptation Convergence	64,530	3.5%	50,320	10.2%	8,965	3.2%	5,245	0.5%	-	0.0%

(unit: KRW million won)

Class	Division	2013									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)
Total		1,894,190	100.0%	567,001	100.0%	302,179	100.0%	963,832	100.0%	61,178	100.0%
Mitigation	Subtotal	1,753,802	92.6%	504,826	89.0%	283,271	93.7%	904,550	93.8%	61,155	100.0%
	1. Non-renewable energy	69,708	3.7%	55,966	9.9%	894	0.3%	-	0.0%	12,848	21.0%
	2. Renewable energy	286,497	15.1%	10,971	1.9%	50,583	16.7%	187,148	19.4%	37,796	61.8%
	3. New energy	44,706	2.4%	2,174	0.4%	2,760	0.9%	39,724	4.1%	48	0.1%
	4. Energy storage	265,978	14.0%	146,975	25.9%	25,575	8.5%	92,977	9.6%	451	0.7%
	5. Transmission and distribution and energy management	108,024	5.7%	42,153	7.4%	7,842	2.6%	54,481	5.7%	3,548	5.8%
	6. Energy demand	958,887	50.6%	246,557	43.5%	175,669	58.1%	530,221	55.0%	6,440	10.5%
	7. Greenhouse gas fixation	20,001	1.1%	29	0.0%	19,949	6.6%	-	0.0%	23	0.0%
Adaptation	Subtotal	66,730	3.5%	8,599	1.5%	6,894	2.3%	51,213	5.3%	23	0.0%
	8. Agriculture and animal husbandry	13,069	0.7%	32	0.0%	1,629	0.5%	11,408	1.2%	-	0.0%
	9. Water	53,660	2.8%	8,567	1.5%	5,265	1.7%	39,805	4.1%	23	0.0%
Mitigation & Adaptation Convergence	Subtotal	73,658	3.9%	53,576	9.4%	12,014	4.0%	8,068	0.8%	-	0.0%
	10. Mitigation & Adaptation Convergence	73,658	3.9%	53,576	9.4%	12,014	4.0%	8,068	0.8%	-	0.0%

(unit: KRW million won)

Class	Division	2014									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)
Total		1,904,750	100.0%	503,564	100.0%	317,854	100.0%	1,024,319	100.0%	59,014	100.0%
Mitigation	Subtotal	1,817,551	95.4%	481,650	95.6%	299,126	94.1%	977,788	95.5%	58,987	100.0%
	1. Non-renewable energy	63,617	3.3%	50,702	10.1%	853	0.3%	-	0.0%	12,062	20.4%
	2. Renewable energy	274,796	14.4%	6,552	1.3%	50,991	16.0%	181,210	17.7%	36,043	61.1%
	3. New energy	47,642	2.5%	2,405	0.5%	2,905	0.9%	42,331	4.1%	-	0.0%
	4. Energy storage	271,808	14.3%	148,068	29.4%	27,521	8.7%	95,310	9.3%	908	1.5%
	5. Transmission and distribution and energy management	119,925	6.3%	44,388	8.8%	9,509	3.0%	61,651	6.0%	4,376	7.4%
	6. Energy demand	1,023,441	53.7%	229,494	45.6%	191,126	60.1%	597,275	58.3%	5,547	9.4%
	7. Greenhouse gas fixation	16,322	0.9%	40	0.0%	16,221	5.1%	10	0.0%	51	0.1%
Adaptation	Subtotal	51,248	2.7%	5,228	1.0%	6,659	2.1%	39,336	3.8%	25	0.0%
	8. Agriculture and animal husbandry	11,996	0.6%	47	0.0%	1,519	0.5%	10,429	1.0%	-	0.0%
	9. Water	39,252	2.1%	5,181	1.0%	5,140	1.6%	28,907	2.8%	25	0.0%
Mitigation & Adaptation Convergence	Subtotal	35,951	1.9%	16,686	3.3%	12,069	3.8%	7,194	0.7%	2	0.0%
	10. Mitigation & Adaptation Convergence	35,951	1.9%	16,686	3.3%	12,069	3.8%	7,194	0.7%	2	0.0%

(unit: KRW million won)

Class	Division	2015									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)
Total		1,937,116	100.0%	464,544	100.0%	338,822	100.0%	1,040,086	100.0%	93,665	100.0%
Mitigation	Subtotal	1,847,585	95.4%	439,816	94.7%	318,534	94.0%	996,051	95.8%	93,183	99.5%
	1. Non-renewable energy	28,495	1.5%	13,623	2.9%	1,041	0.3%	-	0.0%	13,831	14.8%
	2. Renewable energy	314,786	16.3%	9,583	2.1%	55,132	16.3%	186,571	17.9%	63,500	67.8%
	3. New energy	49,787	2.6%	2,555	0.6%	2,805	0.8%	44,426	4.3%	1	0.0%
	4. Energy storage	284,800	14.7%	142,120	30.6%	31,766	9.4%	106,256	10.2%	4,657	5.0%
	5. Transmission and distribution and energy management	110,579	5.7%	41,835	9.0%	8,936	2.6%	55,158	5.3%	4,650	5.0%
	6. Energy demand	1,044,460	53.9%	229,939	49.5%	204,450	60.3%	603,622	58.0%	6,450	6.9%
	7. Greenhouse gas fixation	14,678	0.8%	161	0.0%	14,405	4.3%	18	0.0%	94	0.1%
Adaptation	Subtotal	51,144	2.6%	7,034	1.5%	7,045	2.1%	37,012	3.6%	53	0.1%
	8. Agriculture and animal husbandry	12,596	0.7%	5	0.0%	1,705	0.5%	10,866	1.0%	20	0.0%
	9. Water	38,549	2.0%	7,029	1.5%	5,340	1.6%	26,146	2.5%	33	0.0%
Mitigation & Adaptation Convergence	Subtotal	38,387	2.0%	17,694	3.8%	13,243	3.9%	7,022	0.7%	428	0.5%
	10. Mitigation & Adaptation Convergence	38,387	2.0%	17,694	3.8%	13,243	3.9%	7,022	0.7%	428	0.5%

(unit: KRW million won)

Class	Division	2016									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)
Total		2,041,939	100.0%	499,345	100.0%	383,463	100.0%	1,076,089	100.0%	83,042	100.0%
Mitigation	Subtotal	1,941,463	95.1%	475,855	95.3%	358,289	93.4%	1,024,967	95.2%	82,352	99.2%
	1. Non-renewable energy	67,261	3.3%	49,485	9.9%	1,014	0.3%	-	0.0%	16,762	20.2%
	2. Renewable energy	349,158	17.1%	11,320	2.3%	68,648	17.9%	213,597	19.8%	55,592	66.9%
	3. New energy	53,904	2.6%	2,776	0.6%	3,459	0.9%	47,409	4.4%	260	0.3%
	4. Energy storage	298,408	14.6%	149,855	30.0%	33,977	8.9%	113,605	10.6%	970	1.2%
	5. Transmission and distribution and energy management	106,407	5.2%	44,045	8.8%	10,069	2.6%	47,313	4.4%	4,980	6.0%
	6. Energy demand	1,044,259	51.1%	218,264	43.7%	219,393	57.2%	603,030	56.0%	3,572	4.3%
	7. Greenhouse gas fixation	22,067	1.1%	110	0.0%	21,729	5.7%	12	0.0%	216	0.3%
Adaptation	Subtotal	56,985	2.8%	5,371	1.1%	7,266	1.9%	44,277	4.1%	71	0.1%
	8. Agriculture and animal husbandry	13,194	0.6%	1	0.0%	1,526	0.4%	11,628	1.1%	39	0.0%
	9. Water	43,791	2.1%	5,370	1.1%	5,740	1.5%	32,649	3.0%	32	0.0%
Mitigation & Adaptation Convergence	Subtotal	43,491	2.1%	18,119	3.6%	17,908	4.7%	6,844	0.6%	619	0.7%
	10. Mitigation & Adaptation Convergence	43,491	2.1%	18,119	3.6%	17,908	4.7%	6,844	0.6%	619	0.7%

(unit: KRW million won)

Class	Division	2017									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)	R&D expenses	Share (%)
Total		2,256,393	100.0%	519,095	100.0%	402,527	100.0%	1,221,701	100.0%	113,070	100.0%
Mitigation	Subtotal	2,161,765	95.8%	498,683	96.1%	378,032	93.9%	1,172,600	96.0%	112,450	99.5%
	1. Non-renewable energy	67,256	3.0%	48,202	9.3%	1,013	0.3%	-	0.0%	18,041	16.0%
	2. Renewable energy	431,357	19.1%	11,097	2.1%	78,802	19.6%	268,472	22.0%	72,986	64.5%
	3. New energy	60,452	2.7%	2,607	0.5%	3,270	0.8%	50,920	4.2%	3,655	3.2%
	4. Energy storage	330,039	14.6%	160,599	30.9%	36,016	8.9%	129,039	10.6%	4,384	3.9%
	5. Transmission and distribution and energy management	105,855	4.7%	46,938	9.0%	8,858	2.2%	44,091	3.6%	5,968	5.3%
	6. Energy demand	1,148,851	50.9%	229,245	44.2%	232,276	57.7%	680,064	55.7%	7,266	6.4%
	7. Greenhouse gas fixation	17,955	0.8%	-6	0.0%	17,797	4.4%	14	0.0%	150	0.1%
Adaptation	Subtotal	55,322	2.5%	5,121	1.0%	7,262	1.8%	42,866	3.5%	73	0.1%
	8. Agriculture and animal husbandry	12,858	0.6%	-	0.0%	1,657	0.4%	11,161	0.9%	39	0.0%
	9. Water	42,464	1.9%	5,121	1.0%	5,605	1.4%	31,704	2.6%	34	0.0%
Mitigation & Adaptation Convergence	Subtotal	39,306	1.7%	15,292	2.9%	17,232	4.3%	6,235	0.5%	547	0.5%
	10. Mitigation & Adaptation Convergence	39,306	1.7%	15,292	2.9%	17,232	4.3%	6,235	0.5%	547	0.5%

The Number of Employees in Climate Technology Industry from 2012 to 2017

(unit: people)

Class	Division	2012									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)
Total		184,816	100.0%	67,089	100.0%	67,094	100.0%	44,504	100.0%	6,129	100.0%
Mitigation	Subtotal	173,585	93.9%	65,880	98.2%	64,529	96.2%	37,281	83.8%	5,895	96.2%
	1. Non-renewable energy	3,733	2.0%	1,864	2.8%	183	0.3%	1,316	3.0%	370	6.0%
	2. Renewable energy	49,982	27.0%	16,482	24.6%	17,003	25.3%	13,784	31.0%	2,713	44.3%
	3. New energy	3,942	2.1%	1,789	2.7%	1,123	1.7%	991	2.2%	38	0.6%
	4. Energy storage	32,129	17.4%	23,578	35.1%	3,387	5.0%	5,125	11.5%	38	0.6%
	5. Transmission and distribution and energy management	5,397	2.9%	138	0.2%	3,160	4.7%	1,741	3.9%	358	5.8%
	6. Energy demand	78,091	42.3%	22,009	32.8%	39,609	59.0%	14,108	31.7%	2,365	38.6%
	7. Greenhouse gas fixation	310	0.2%	19	0.0%	64	0.1%	215	0.5%	11	0.2%
Adaptation	Subtotal	7,282	3.9%	72	0.1%	449	0.7%	6,619	14.9%	142	2.3%
	8. Agriculture and animal husbandry	1,346	0.7%	8	0.0%	128	0.2%	1,140	2.6%	69	1.1%
	9. Water	5,936	3.2%	64	0.1%	321	0.5%	5,478	12.3%	73	1.2%
Mitigation & Adaptation Convergence	Subtotal	3,949	2.1%	1,137	1.7%	2,116	3.2%	604	1.4%	92	1.5%
	10. Mitigation & Adaptation Convergence	3,949	2.1%	1,137	1.7%	2,116	3.2%	604	1.4%	92	1.5%

(unit: people)

Class	Division	2013									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)
Total		187,515	100.0%	67,971	100.0%	67,559	100.0%	45,675	100.0%	6,310	100.0%
Mitigation	Subtotal	175,989	93.9%	66,682	98.1%	64,822	95.9%	38,412	84.1%	6,073	96.2%
	1. Non-renewable energy	3,929	2.1%	2,011	3.0%	173	0.3%	1,354	3.0%	391	6.2%
	2. Renewable energy	48,567	25.9%	15,676	23.1%	16,086	23.8%	13,999	30.6%	2,806	44.5%
	3. New energy	3,900	2.1%	1,645	2.4%	1,280	1.9%	931	2.0%	43	0.7%
	4. Energy storage	33,670	18.0%	24,547	36.1%	3,521	5.2%	5,561	12.2%	41	0.6%
	5. Transmission and distribution and energy management	5,373	2.9%	141	0.2%	3,020	4.5%	1,838	4.0%	374	5.9%
	6. Energy demand	80,214	42.8%	22,646	33.3%	40,663	60.2%	14,499	31.7%	2,406	38.1%
	7. Greenhouse gas fixation	338	0.2%	17	0.0%	80	0.1%	229	0.5%	12	0.2%
Adaptation	Subtotal	7,279	3.9%	71	0.1%	451	0.7%	6,615	14.5%	142	2.3%
	8. Agriculture and animal husbandry	1,486	0.8%	2	0.0%	127	0.2%	1,288	2.8%	69	1.1%
	9. Water	5,794	3.1%	69	0.1%	324	0.5%	5,327	11.7%	74	1.2%
Mitigation & Adaptation Convergence	Subtotal	4,247	2.3%	1,218	1.8%	2,286	3.4%	648	1.4%	95	1.5%
	10. Mitigation & Adaptation Convergence	4,247	2.3%	1,218	1.8%	2,286	3.4%	648	1.4%	95	1.5%

(unit: people)

Class	Division	2014									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)
Total	Total	192,815	100.0%	70,368	100.0%	69,639	100.0%	46,154	100.0%	6,654	100.0%
Mitigation	Subtotal	181,306	94.0%	69,105	98.2%	66,978	96.2%	38,812	84.1%	6,412	96.4%
	1. Non-renewable energy	3,754	1.9%	1,977	2.8%	145	0.2%	1,224	2.7%	410	6.2%
	2. Renewable energy	51,910	26.9%	16,026	22.8%	18,692	26.8%	14,200	30.8%	2,991	45.0%
	3. New energy	3,953	2.1%	1,658	2.4%	1,302	1.9%	940	2.0%	53	0.8%
	4. Energy storage	35,491	18.4%	26,230	37.3%	3,580	5.1%	5,632	12.2%	48	0.7%
	5. Transmission and distribution and energy management	5,340	2.8%	137	0.2%	2,902	4.2%	1,901	4.1%	400	6.0%
	6. Energy demand	80,504	41.8%	23,061	32.8%	40,265	57.8%	14,682	31.8%	2,496	37.5%
	7. Greenhouse gas fixation	355	0.2%	17	0.0%	92	0.1%	232	0.5%	13	0.2%
Adaptation	Subtotal	7,254	3.8%	71	0.1%	436	0.6%	6,603	14.3%	144	2.2%
	8. Agriculture and animal husbandry	1,415	0.7%	2	0.0%	126	0.2%	1,218	2.6%	70	1.0%
	9. Water	5,839	3.0%	70	0.1%	310	0.4%	5,385	11.7%	74	1.1%
Mitigation & Adaptation Convergence	Subtotal	4,255	2.2%	1,192	1.7%	2,225	3.2%	740	1.6%	99	1.5%
	10. Mitigation & Adaptation Convergence	4,255	2.2%	1,192	1.7%	2,225	3.2%	740	1.6%	99	1.5%

(unit: people)

Class	Division	2015									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)
Total	Total	194,410	100.0%	71,664	100.0%	69,114	100.0%	46,712	100.0%	6,920	100.0%
Mitigation	Subtotal	183,072	94.2%	70,386	98.2%	66,603	96.4%	39,400	84.3%	6,683	96.6%
	1. Non-renewable energy	3,805	2.0%	1,891	2.6%	157	0.2%	1,327	2.8%	431	6.2%
	2. Renewable energy	55,475	28.5%	18,951	26.4%	19,171	27.7%	14,186	30.4%	3,167	45.8%
	3. New energy	3,566	1.8%	1,228	1.7%	1,314	1.9%	962	2.1%	62	0.9%
	4. Energy storage	35,243	18.1%	26,043	36.3%	3,447	5.0%	5,691	12.2%	62	0.9%
	5. Transmission and distribution and energy management	4,783	2.5%	137	0.2%	2,399	3.5%	1,833	3.9%	415	6.0%
	6. Energy demand	79,831	41.1%	22,119	30.9%	40,016	57.9%	15,163	32.5%	2,533	36.6%
	7. Greenhouse gas fixation	368	0.2%	17	0.0%	99	0.1%	239	0.5%	14	0.2%
Adaptation	Subtotal	7,301	3.8%	69	0.1%	436	0.6%	6,652	14.2%	144	2.1%
	8. Agriculture and animal husbandry	1,448	0.7%	1	0.0%	128	0.2%	1,248	2.7%	71	1.0%
	9. Water	5,853	3.0%	68	0.1%	308	0.4%	5,404	11.6%	72	1.0%
Mitigation & Adaptation Convergence	Subtotal	4,038	2.1%	1,209	1.7%	2,075	3.0%	660	1.4%	93	1.3%
	10. Mitigation & Adaptation Convergence	4,038	2.1%	1,209	1.7%	2,075	3.0%	660	1.4%	93	1.3%

(unit: people)

Class	Division	2016									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)
Total	Total	197,867	100.0%	72,275	100.0%	68,485	100.0%	49,897	100.0%	7,210	100.0%
Mitigation	Subtotal	185,669	93.8%	70,968	98.2%	65,984	96.3%	41,742	83.7%	6,975	96.7%
	1. Non-renewable energy	4,060	2.1%	1,891	2.6%	227	0.3%	1,467	2.9%	475	6.6%
	2. Renewable energy	55,092	27.8%	19,277	26.7%	17,280	25.2%	15,246	30.6%	3,288	45.6%
	3. New energy	3,977	2.0%	1,553	2.1%	1,305	1.9%	1,040	2.1%	79	1.1%
	4. Energy storage	35,147	17.8%	25,607	35.4%	3,492	5.1%	5,983	12.0%	66	0.9%
	5. Transmission and distribution and energy management	5,035	2.5%	134	0.2%	2,465	3.6%	2,005	4.0%	431	6.0%
	6. Energy demand	81,953	41.4%	22,492	31.1%	41,114	60.0%	15,725	31.5%	2,622	36.4%
	7. Greenhouse gas fixation	406	0.2%	13	0.0%	103	0.2%	275	0.6%	15	0.2%
Adaptation	Subtotal	8,099	4.1%	98	0.1%	477	0.7%	7,376	14.8%	149	2.1%
	8. Agriculture and animal husbandry	1,516	0.8%	-	0.0%	142	0.2%	1,298	2.6%	76	1.0%
	9. Water	6,584	3.3%	98	0.1%	335	0.5%	6,078	12.2%	73	1.0%
Mitigation & Adaptation Convergence	Subtotal	4,098	2.1%	1,209	1.7%	2,024	3.0%	780	1.6%	85	1.2%
	'10. Mitigation & Adaptation Convergence	4,098	2.1%	1,209	1.7%	2,024	3.0%	780	1.6%	85	1.2%

(unit: people)

Class	Division	2017									
		All		Large company		Middle standing company		Small and medium-sized company		Non-profit organizations (research institutes, etc.)	
		Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)	Number of Employees	Share (%)
Total	Total	197,615	100.0%	71,298	100.0%	68,196	100.0%	50,922	100.0%	7,199	100.0%
Mitigation	Subtotal	185,286	93.8%	69,988	98.2%	65,794	96.5%	42,542	83.5%	6,963	96.7%
	1. Non-renewable energy	4,079	2.1%	1,854	2.6%	233	0.3%	1,504	3.0%	488	6.8%
	2. Renewable energy	54,862	27.8%	18,331	25.7%	17,277	25.3%	15,697	30.8%	3,557	49.4%
	3. New energy	3,992	2.0%	1,565	2.2%	1,284	1.9%	1,071	2.1%	73	1.0%
	4. Energy storage	36,001	18.2%	26,165	36.7%	3,528	5.2%	6,233	12.2%	75	1.0%
	5. Transmission and distribution and energy management	4,878	2.5%	137	0.2%	2,384	3.5%	1,889	3.7%	467	6.5%
	6. Energy demand	81,060	41.0%	21,932	30.8%	40,999	60.1%	15,843	31.1%	2,286	31.7%
	7. Greenhouse gas fixation	415	0.2%	4	0.0%	89	0.1%	305	0.6%	16	0.2%
Adaptation	Subtotal	8,333	4.2%	101	0.1%	507	0.7%	7,579	14.9%	145	2.0%
	8. Agriculture and animal husbandry	1,630	0.8%	-	0.0%	144	0.2%	1,414	2.8%	72	1.0%
	9. Water	6,703	3.4%	101	0.1%	363	0.5%	6,165	12.1%	74	1.0%
Mitigation & Adaptation Convergence	Subtotal	3,996	2.0%	1,209	1.7%	1,895	2.8%	800	1.6%	92	1.3%
	10. Mitigation & Adaptation Convergence	3,996	2.0%	1,209	1.7%	1,895	2.8%	800	1.6%	92	1.3%

2.1. Conclusions - Implications of Climate Technology Industry Statistics

▶ **The sales of the climate technology industry showed an annual average of about 165,065 billion won from 2012 to 2017, representing a decreasing trend of -0.03% in annual average growth rate.**

- Industries related climate technology showed a decrease in sales amount at the annual sales growth rate in the greenhouse gas mitigation, adaptation to climate change and convergence industries (0.14%, -1.51%, -2.74%, respectively).
- The annual average sales of large and middle standing companies decreased by -0.36% and -1.11%, respectively, followed by an increase of 4.70% in small and medium-sized companies.

▶ **It was found that companies involved in climate technology have been investing in R&D an annual average of about 1,975 billion won annually from 2012 to 2017, showing an average annual increase of 4.40%.**

- R&D investment in industries related climate technology has been on the rise in mitigation and adaptation sectors at an average annual growth rate of 3.34% and 2.25%, respectively, and the convergence sector has decreased by -9.39%.
- The average annual growth rate of the number of workers in industries related climate technology of large companies, middle standing companies, small and medium-sized companies, and others is increasing by 1.03%, 7.64%, 4.46%, and 11.66%, respectively.

▶ **In the climate technology industry, an annual average of 192,506 people were engaged from 2012 to 2017, and the annual average growth rate was 1.35%.**

- The annual average growth rate of the number of employees in industries related climate technology was 1.31% in the sector of mitigation, 2.73% in the adaptation sector and 0.24% in the convergence sector. All showed an increasing tendency.
- The average annual growth rate of the number of employees of large corporations, middle standing companies, small and medium-sized companies, others is increasing by 1.22%, 0.33 2.73%, and 3.27%.

Appendix 1
Description of Climate Technology

1. Nuclear Power Generation

Technology definition	A technology to design, construct and operate nuclear power plants with stability, economic efficiency and environmental friendliness by upgrading nuclear power plants, facilities that produce electricity using fission energy.
Keywords	SFR (Sodium-cooled Fast Reactor), VHTR (Very High Temperature Reactor), Nuclear Fusion Reactor, LFR (Lead-cooled Fast Reactor), ADS, Advanced PWR (Pressurized Water Reactor), SF (Spent Fuel, Used Nuclear Fuel), Advanced nuclear recycle system, High level (radioactive) waste, Decommissioning, Pyro-processing, Metal fuel, Transmutation of long-lived Radionuclide, Transuranic element, Final disposal, Interim storage.
Related sub-technology	1. Future reactor system (Gen IV) 2. Circulating nuclear fuel cycle system (SF recycling, high level waste management) 3. Next-generation light water reactor 4. Nuclear disassembly technology

2. Fusion Power Generation

Technology definition	A technology for producing electric power or hydrogen by recovering the energy of neutrons safely and effectively in the form of heat energy through the control of the fusion reaction occurring in the high-temperature plasma state of deuterium- tritium, and utilizing high-energy neutrons.
Keywords	Blanket, Tritium fuel cycle, Low activation material, Power conversion
Related sub-technology	1. Nuclear fusion reactor core technology 2. Nuclear fusion reactor system integration technology 3. Heating and diagnostic device technology 4. Superconducting magnet technology 5. Nuclear fusion material technology 6. Power system engineering technology 7. Fusion cycle fuel cycle technology 8. Safety and Licensing Technology

3. Clean Power Generation and Efficiency

Technology definition	High-efficiency clean fossil fuel technology that can achieve CO_2 reduction through fuel diversification by biomass co-firing, high efficiency compared to conventional thermal power generation, fossil fuel purification, CO_2 recirculation, etc.
Keywords	High efficiency generation, Ultrasupercritical (USC) generation, Integrated Gasification Combined Cycle (IGCC), Fluidized Bed Combustion (FBC), Integrated Gasification Fuel Cell (IGFC), Biomass co-firing, Oxy-fuel combustion, High efficiency gas turbine, Clean Coal Technology (CCT)
Related sub-technology	1. High efficiency generation, Ultrasupercritical (USC) generation technology 2. Integrated Gasification Combined Cycle (IGCC) generation technology 3. Coal-to-liquids (CTL) and gasification technology 4. Fluidized bed power generation technology 5. Biomass co-firing technology 6. Oxy-fuel combustion technology 7. Integrated Gasification Fuel Cell (IGFC) technology 8. Clean coal technology

4. Hydropower

Technology definition	Various technologies to convert energy by utilizing the potential energy of water in dams, rivers or watersheds.
Keywords	Hydropower, Runner, Generator, Small hydro power
Related sub-technology	1. Hydraulic turbine design and manufacturing technology 2. Generator design and manufacturing technology 3. Hydropower resources research technology 4. Hydraulic power system control technology

5. Photovoltaic

Technology definition	A technology to convert solar light energy directly into electric energy by using photovoltaic generation system (consisting of solar cell, module, battery and power regulator, and AC/DC converter).
Keywords	Solar cell, Module, Inverter, c-Si solar cell, Compound solar cell, Organic solar cell, High efficiency
Related sub-technology	1. Silicon solar cell (crystalline/amorphous) 2. Thin film solar cell (silicon thin film/CdTe/CIGS/dye-sensitized/organic) 3. Next-generation solar cells (high-efficiency compound/perovskite)

6. Solar Thermal

Technology definition	Various technologies concerning conversion, storage and utilization of solar radiation into useful thermal energy.
Keywords	Solar heat collecting, Concentrating solar heat, Solar photovoltaic thermal hybrid, Solar thermal storage, Solar water heating, Solar space heating, Solar space cooling, Solar thermal desalination, Solar process heat, Solar active house, Solar district heating, Concentrating solar power generation, Solar fuel
Related sub-technology	1. Mid- and low-temperature small-scale solar heat - Thermal collectors, heat storage (high efficiency, chemical storage, etc.), utilization (individual building house warm water, heating and cooling) 2. Mid- and low-temperature large-scale solar heat - Heat collecting complex, large-scale thermal storage (seasonal thermal storage), utilization (district heating, process heat) 3. Mid-Light condensing and high-temperature large-scale solar heat - Heat collection, high-temperature heat storage, utilization (power generation, fuel)

7. Geothermal

Technology definition	A technology to produce electricity or heat by using water, underground water and underground heat or temperature difference.
Keywords	Geothermal, Geothermal energy, Geothermal power generation, Geothermal direct-use, Deep geothermal, Geothermal heating and cooling, Geothermal (ground-source) heat pump, Enhanced geothermal system (EGS), Hydrothermal resources, Underground thermal energy storage (UTES)
Related sub-technology	1. Shallow geothermal heat utilization technology (geothermal heating and cooling / underground thermal energy storage) 2. Deep geothermal heat development and utilization, and geothermal power generation technology 3. Geothermal fusion technology

8. Wind Power

Technology definition	Power generation technology that generates electricity by converting kinetic energy of wind, which is absorbed by the rotor blades, into mechanical energy.
Keywords	Wind turbine, Wind farm, On-shore wind power generation, Off-shore wind power generation, Floating wind power generation, Wind resource assessment, Wind resource measurement, Blade, Tower, Gearbox, Generator, Nacelle, Drive-train, Certification, Design assessment, Power curve, Power coefficient, Field test, Test bed, Low speed wind turbine, Large wind turbine, Small wind turbine, Horizontal wind turbine, Axial wind turbine, Controller, Offshore cable, On-shore power station, Off-shore power station, Maintenance, Levelized cost of energy, Economic analysis, Project feasibility study
Related sub-technology	1. Onshore Wind Power 2. Offshore Wind Power 3. Floating wind power 4. Wind energy convergence

9. Ocean Energy

Technology definition	Relevant technology for practical use of ocean clean energy, that does not emit carbon dioxide, such as tidal force, wave power, ocean thermal temperature difference, sea water salinity difference, and ocean current.
Keywords	Tidal current power, Tidal barrage power, Wave power, Seawater cooling/heating, OTEC (Ocean Thermal Energy Convention), Salinity gradient power
Related sub-technology	1. Tidal barrage power 2. Tidal current power 3. Wave power 4. Sea current power 5. Ocean Thermal Energy Convention (OTEC) 6. Sea Water Air Conditioning (SWAC) 7. Salinity gradient power

10. Bioenergy

Technology definition	An alternative energy source technology that can replace fossil energy by applying thermochemical or biological conversion techniques from animals, plants, or derived resources (biomass) and marine biomass.
Keywords	Biomass, Bioenergy, Biofuel, Bioalcohol, Bioethanol, Biobutanol, Biogas, Biomethane, Bio-hydrogen, Biorefinery, Biodiesel, Bio-jet fuel, Wood chip, Wood pellet, Pretreatment, Saccharification, Lignin, Lignocellulose
Related sub-technology	1. Biomass power generation technology (heat/power generation technology using biomass) 2. Transport fuel production technology (bio-alcohol, biodiesel, biogas, high-carbon biofuel)

11. Waste Energy

Technology definition	Waste is obtained by using flammable waste of high calorific value generated from daily life and business activities. Waste Energy Technology (WTE) means technology of converting combustible waste with high energy content into waste energy.
Keywords	Waste energy, Waste energy technology, Waste Fuel technology, Solid refuse fuel, Pyrolysis gasification, Pyrolysis liquefaction
Related sub-technology	1. Direct energy recovery technology (cement kiln, incineration heat recovery, solid fuel power plant) 2. Solid Fuel Manufacturing Technology 3. Refining and emulsifying technology (refining and emulsifying fuel manufacturing) 4. Pyrolysis technology (carbonization, liquefaction, gasification) 5. Biological conversion technology (biogasification, ethanolification, etc.) 6. Power plant fuel technology

12. Hydrogen Manufacturing

Technology definition	A technology to manufacture hydrogen by converting fossil fuel or decomposing water by thermochemical, photochemical-thermochemical, photochemical, electrochemical, biological, and chemical methods.
Keywords	Hydrogen production, Water electrolysis, Solar hydrogen fuel, Photoelectrochemical hydrogen generation, Reforming, Nuclear hydrogen production, Photocatalyst- enzyme-microbial hydrogen generation
Related sub-technology	1. Fossil fuel reforming technology 2. Biological hydrogen production technology (biomass) 3. Water-electrolytic hydrogen production technology

13. Fuel Cell

Technology definition	A technology to simultaneously produce electricity and heat with high generation efficiency and low emission by directly converting the chemical energy of fuel (hydrogen, methanol, coal, natural gas, petroleum, biomass gas, landfill gas, etc.) into electric energy through electrochemical reaction.
Keywords	Fuel Cell, Solid Oxide Fuel Cell (SOFC), Ceramic Fuel Cell, Alkaline Fuel Cell (AFC), Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC), Polymer Electrolyte Membrane Fuel Cell (PEMFC), Direct Methanol Fuel Cell (DMFC), Direct Carbon Fuel Cell (DCFC), Bio Fuel Cell (BFC)
Related sub-technology	1. Alkaline Fuel Cell (AFC) 2. Phosphoric Acid Fuel Cell (PAFC) 3. Molten Carbonate Fuel Cell (MCFC) 4. Solid Oxide Fuel Cell (SOFC) 5. Polymer Electrolyte Membrane Fuel Cell (PEMFC) 6. Direct Methanol Fuel Cell (DMFC) 7. System (Reformer, Stack, Power Converter, BOP)

14. Power Storage

Technology definition	A technology that includes energy storage technology and peripheral device technology that can reduce the greenhouse gas emissions by improving electric power quality and maximizing energy efficiency by storing and using electric energy with high efficiency.
Keywords	Power storage technology, Power storage system, Energy storage system, Power control system
Related sub-technology	1. Chemical storage (lithium-based, non-lithium-based) 2. Physical storage (CAES, FWES, SMES)

15. Hydrogen Storage

Technology definition	Techniques to safely and efficiently store produced hydrogen in compression, liquefaction, adsorption using media and storage or in the form of hydrogen compounds.
Keywords	Hydrogen storage, Physisorption, Metal hydrides, Chemical hydrides, Hydrogen storage alloys, Compressed hydrogen storage, Liquid hydrogen storage, Chemical hydrogen storage, Dehydrogenation. Hydrogenation, Liquified hydrogen storage, Compressed (Pressurized) hydrogen storage
Related sub-technology	1. Hydrogen storage technology for transport 2. Stationery hydrogen storage technology 3. Portable hydrogen storage technology

16. Transmission and Distribution System

Technology definition	A technology to develop digital and intelligent power system and heavy electric machine as well as high value added electric power service by introducing information and communication technology and automation system into power technology such as power generation, transmission and distribution, including parts and system technology development, and intelligent power monitoring and control technology.
Keywords	Smart Grid, WAMS (Wide Area Monitoring & Measurement System), FACTS (Flexible AC Transmission System), HVDC (High Voltage Direct Current)
Related sub-technology	1. HVDC technology 2. Smart City 3. Distributed power integration system 4. Flexible transmission network system 5. Wide area monitoring/control/ protection system 6. Power IT security system 7. Hydrogen storage technology for transport 8. Stationery hydrogen storage technology 9. Portable hydrogen storage technology

17. Electric Intelligence Device

Technology definition	Products, technologies, systems, and linkage technologies to reduce energy use losses and maximize energy saving effects.
Keywords	EMS (Energy Management System), ESS (Energy Storage System), AMI (Advanced Metering Infrastructure), UPS (Uninterruptible Power Supply)
Related sub-technology	1. AMI 2. UPS 3. Superconducting equipment 4. ESS and EMS linkage technology 5. Other intelligent devices

18. Transport Efficiency

Technology definition	Techniques to safely and efficiently store produced hydrogen in compression, liquefaction, adsorption using media and storage or in the form of hydrogen compounds.
Keywords	Mobility, Accessibility, Traffic safety, ITS (Intelligent transport system), C-ITS, Emission, Traffic information, Traffic congestion, Transit, Logistics, Traffic accidents, Eco-friendly, Energy efficient, Weight lightening, Renewable energy application, Efficiency, Fuel efficiency (reduction), Emission reduction, electric, HEV, Transportation System, Vehicle, The next generation of car, Eco-friendly ship, High efficiency locomotive, Gas engine, Near low emission diesel engine, Dual-fuel engine, High efficiency on power transmission, High efficiency motor, The next generation of power source, Lighter and stronger material, Advanced materials technology, Intelligent transportation system, Intelligent logistics systems, Intelligent navigation systems
Related sub-technology	1. Transportation System (ITS) 2. Next-generation vehicles 3. High-efficiency railway 4. Environment-friendly vessels 5. Low-carbon air traffic

19. Industrial efficiency

Technology definition	Infrastructure technology suitable for conversion to the industrial structure that links low-carbon type raw material substitution considering the whole process from raw material collection to post production waste disposal and recycling and integrated high efficiency new processing in order to fundamentally reduce the energy that is injected and distributed in various forms in the industrial sector, which is the processing body of petroleum and resources.
Keywords	Process optimization, Carbon-neutral feedstock, Renewable raw material and product, Manufacturing life cycle, Resource and energy circulation, New innovative process, High energy efficiency, Recycling and resource, Waste minimization and valorization, New and renewal energy utility, Inter-industrial resource and energy exchange, Sustainable industry, Energy Efficiency, Eco-friendly process, Clean technology, Process technology, Energy saving, Low GWP, Eco-friendly material, Energy efficient device (or unit), Eco-friendly fuel, Waste minimization, Waste reuse, Life cycle analysis, Emission minimization, Waste heat recovery, Process optimization, Process Efficiency, Green process
Related sub-technology	1. Improvement of process energy efficiency ((1) High-efficiency technology for manufacturing equipment, (2) Optimization technology for manufacturing process efficiency, (3) FEMS (Factory Energy Management System)) 2. New process technology (① Process exhaust gas reduction technology (including hydrogen reduction steel technology) ② New catalyst technology ③ Fourth industrial process technology) 3. Raw material substitution technology (① Biomass-derived chemical production technology, ② CO_2-derived chemical production technology, ③ Natural gas-derived refining technology) 4. Byproduct waste and resource circulation technology (① Process, product byproducts and waste value-added technology (resource recovery and material recycling) ② Process energy recovery and reuse technology (combined heat and power, etc. ③ Process-plant-region energy integration networking technology)

20. Building efficiency

Technology definition	A technology for optimizing energy efficiency of core parts and existing buildings in the expansion of zero energy building.
Keywords	Building energy efficiency, Passive, Active, Energy management, Renewable, Wall, Window, lighting, Monitoring, BEMS, HEMS, BIPV, Geothermal, LED, Insulation, HVAC, Window, Sunshade, Pump, Fan, Renewable energy, Cooling & heating system, High efficiency system, Zero energy house, Plus energy house, Ecological architecture, Passive house, Zero energy building, Eco industrial complex, Resource recycling, Zero energy, Carbon neutralization, Green House Gas, New regeneration energy, Green remodeling, Resources recycling, Sustainability, Resources Saving, life cycle assessment, Smart grid
Related sub-technology	1. Active architecture (lighting, air conditioning system) 2. Passive construction (window (envelope), insulation (material), shade) 3. House and building energy management (HEMS, BEMS) 4. Renewal of buildings (Renewable energy facilities such as photovoltaic, wind, etc.)

21. CCUS

Technology definition	A technology that captures CO_2 from mass sources, compresses and transports it to safely store it in land or marine environment, directly use it, or converts it directly into useful materials
Keywords	Post-combustion, Pre-Combustion, Oxy-fuel, Capture, Separation, Absorption, Adsorption, Membrane, CO_2, Chemical conversion, Biological conversion, Mineralization, Utilization
Related sub-technology	1. CO_2 capture technology 2. CO_2 transport technology 3. CO_2 storage technology 4. CO_2 (direct) utilization technology 5. CO_2 conversion technology

22. Non-CO_2 Reduction

Technology definition	A technology to collect, refine, utilize and decompose processing technologies and to develop alternatives materials and alternative processes that can improve emissions from its source to monitor and database the status of non-CO_2 greenhouse gases and to reduce them.
Keywords	Non-CO_2, CH_4, N_2O, SF_6, HFC, PFC, Refrigerant, Foaming agent, Landfill gas (LFG), Anaerobic digestion, Manure, Sewage sludge, Nitric acid process, Semi conductor flue gas, Display industry, Gas Insulator Switch (GIS), HFCs, PFCs, NF_3, GWI, F-gas, Plasma, SCR (Selective Catalytic Reduction), Reclaimer, Reclaimed gas, Recovery, Storage, Reuse, Purity requirement for reuse, Gas quality check, Further treatment, Final disposal, Recycling, Absorbed moisture, Decomposition by-products, Dew point temperature
Related sub-technology	1. CH_4 capture and utilization abatement technology 2. N_2O transport technology 3. Reduction technology of fluorinated gas (HFCs, PFCs, SF_6, NF_3) 4. Non-CO_2 greenhouse gas integrated management technology

23-26. Agriculture and animal husbandry

Technology definition	A technology that is required to understand the impacts of climate change on crops and livestock production as well as technologies that minimize adverse impacts such as reduced agricultural and livestock productivity by climate change.
Keywords	Crop productivity, Chemical fertilizer/pesticide, Agricultural product postharvest/ storage/distribution, Livestock management, Livestock byproducts/waste, Biotic and abiotic stresses, Genetic resource and genetic improvement, Agricultural biotechnology
Related sub-technology	1. Genetic resources and genetic improvement 2. Crop cultivation and production 3. Livestock rearing management 4. Processing/storage/distribution/consumption of agricultural and livestock products

27-30. Water management

Technology definition	A technology related to water quality improvement, water resources, water storage and supply, etc. in order to address regional and seasonal water quality degradation and water imbalance, excess and shortage due to climate change.
Keywords	Drinking water, Wastewater, Blackish waster, Water reuse, Wastewater reclamation, Water resource, Desalination, Water treatment, Wastewater treatment, Lake, River, Stream, Reservoir, Watershed, Ground water, Hydrological ecology, Water quality, Toxicity, Biological treatment, Physical treatment, Chemical treatment, Non-point source, Point source, Nitrogen, Phosphorus, Micro-pollutant, Advanced oxidation, Sewer, Overflow, Algae, Green algae, Dam, Rain harvest, Heavy metal, TOC, Sludge, Endocrine disrupting Chemicals, Hydrological cycle, Surface water, Run off, Flood, Drought, Water supply, Water demand, Integrated water management, Smart water grid, Low impact development, Landfill leachate, Dissolved oxygen, Climate change, Water quality improvement, Alternative water resources, Water sustainability
Related sub-technology	1. Water and aquatic ecosystem management 2. Securing and supplying water resources 3. Water treatment 4. Water disaster management

31-32. Climate change forecast and monitoring

Technology definition	A technology for tracking, diagnosing and predicting past, present and future climate patterns through observation, monitoring and analysis of natural and anthropogenic factors of climate change and numerical modeling of factors that change the global climate system.
Keywords	Earth system model, Regional climate model, Numerical modeling, Seamless prediction, Coupled model, Climate model, Atmospheric model, Ocean model, Land surface model, Sea ice model, Biogeochemistry, Climate change scenario, Projection, Historical run, Pre-industrial control run, Detection, Attribution, Climate extreme, Green house gas, Aerosol, Climate variability, Climate sensitivity, Satellite observation, Carbon tracker
Related sub-technology	1. Climate change monitoring 2. Climate change information system

33-35. Marine, fisheries, and coastal

Technology definition	A technology including R&D and policy projects required to strengthen science capacity and establish adaptation strategy in response to climate change in marine/ fishery/coastal management fields.
Keywords	Subtropical, Ecosystem change, Sea level rise, Sea temperature rise, Coastal disaster, Storm surge, Coastal flooding
Related sub-technology	1. Marine ecosystem 2. Fisheries resources 3. Coastal disaster response

36-37. Health

Technology definition	A technology that can be used to prevent a wide range of diseases caused by environmental changes due to climate change.
Keywords	Vector borne transmission, Arbovirus infection, Dengue fever, Zika virus, Malaria, Water borne disease
Related sub-technology	1. Infectious diseases management 2. Food safety through prevention

38-40. Forest/land

Technology definition	A technology to maintain and promote forest health and diversity in the long term by conserving the biodiversity, promoting the absorption and storage of carbon dioxide in the atmosphere and reducing the damage caused by disasters and pests, in a complicated system where carbon is absorbed and stored but the system could be a source of emission due to human impacts such as damages or disasters or maladjustment to climate change.
Keywords	Insects, Disease. Forest fire, Landslide, Mountain meteorology, Endangered species, Invasive alien species, Phenology, Restoration, Baekdu-Daegan, Protected area, Mountain meteorology, Species distribution model, Disease and insects, Forest fire, Forest biodiversity, Non-timber products, Harvested wood product (HWP), REDD+, Forest management, Impact assessment of forest sector, Urban forest
Related sub-technology	1. Forestry production enhancement 2. Forest damage reduction 3. Ecological monitoring and restoration

41-45. Multi-disciplinary convergence

Technology definition	A technology that includes low-power consumption equipment and energy harvesting technologies, as well as technologies related to power, heat and gas supply management systems (renewable energy hybrid systems) that combine energy storage systems with two or more energy production systems including renewable energy.
Keywords	New and renewable energy hybrid system, Energy harvesting, Micro-power device, Artificial photosynthesis
Related sub-technology	1. Renewable energy hybrid system 2. Household·Small·Low-power consumption equipment 3. Energy harvesting 4. Artificial photosynthesis 5. Other climate change related technologies not covered in this classification

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