2021

National Communication of the Republic of China (Taiwan) under the United Nations Framework Convention on Climate Change

2021

National Communication of the Republic of China (Taiwan) under the United Nations Framework Convention on Climate Change

Table of contents

Table of contents 00
List of tables. 02
List of figures 04
Executive Summary 08

Chapter 1 National Conditions and Basic Environmental Information 16

1.1 Government organization and legislation 17
1.2 Population 18
1.3 Geographical location and land use 19
1.4 Climate 20
1.5 Economy and industry 22
1.6 Energy 24
1.7 Transportation 25
1.8 Buildings and urban structures 29
1.9 Waste 29
1.10 Agriculture, forestry, fishery, and animal husbandry 30

Chapter 2 Statistics and Trend Analysis of Greenhouse Gas Emissions and Absorption 33

2.1 Greenhouse Gas Inventory Compilation Process and Statistical Method 34
2.2 Statistics on Greenhouse Gas Emissions and Removals 36
2.3 Statistics on Greenhouse Gas Emissions and Removals by Gas 39
2.4 Inventory of Greenhouse Gas Emissions and Absorption Statistics by Sector 49
2.5 Greenhouse Gas Key Sources and Trend Analysis 62

Chapter 3 Greenhouse Gas Reduction Policies and Measures in Taiwan 63

3.1 Taiwan's position in fighting against climate change 64
3.2 The governance structure for climate change 65
3.3 Greenhouse gas reduction policies and measures 75

Chapter 4 Greenhouse Gas Emission Prediction 95

4.1 Emission pathway prediction....96
4.2 Reduction effectiveness evaluation....97
4.3 Prediction method....98

Chapter 5 Impacts of Climate Change and Adaptation Measures 107

5.1 Climate change hazards....108
5.2 Impact of climate change....118
5.3 Adaptation measures and results....121

Chapter 6 Climate Change Scientific Research and Observations 132

6.1 Climate Change Scientific Research....133
6.2 Climate change meteorological observation....139

Chapter 7 International Collaboration and Exchanges 147

7.1 Participation in the United Nations Framework Convention on Climate Change....148
7.2 Collaboration and exchanges between countries and intergovernmental organizations....150
7.3 Cooperation and exchanges between local governments and cities....155
7.4 Non-intergovernmental organization cooperation and exchanges....156

Chapter 8 Education, Training and Communication with the Public 162

8.1 Education....163
8.2 Training....170
8.3 Social dialogue and public communication....174

List of tables

Table 1.5-1: Taiwan's economic growth rate from 2005 to 2020.....22
Table 1.6-1: Energy supply in past years (by energy type).....24
Table 1.6-2: Energy consumption in past years (by energy type).....25
Table 1.6-3: Energy efficiency indicators of Taiwan.....26
Table 1.7-1: Taiwan transportation statistics.....26
Table 1.7-2: Statistics of land transportation volume in 2020.....27
Table 2.1-1 Responsible units of the National Greenhouse Gas Inventory.....35
Table 2.2-1 Emissions and removals of various greenhouse gases in Taiwan from 1990 to 2019.....37
Table 2.3.1-1 Taiwan's CO_2 emissions from 1990 to 2019.....40
Table 2.3.2-1 Taiwan's methane emissions from 1990 to 2019.....43
Table 2.3.3-1 Taiwan's nitrous oxide emissions from 1990 to 2019.....44
Table 2.3.4-1 Taiwan's hydrofluorocarbons emissions from 1990 to 2019.....46
Table 2.3.5-1 Taiwan's perfluorocarbons emissions from 1990 to 2019.....47
Table 2.3.6-1 Taiwan's sulfur hexafluoride emissions from 1990 to 2019.....48
Table 2.3.7-1 Taiwan's nitrogen trifluoride emissions from 1990 to 2019.....49
Table 2.4-1 Taiwan's greenhouse gas emissions by sector in the 1990 to 2019 inventory.....50
Table 2.4.1-1 Greenhouse gas emissions by energy sector in Taiwan from 1990 to 2019.....53
Table 2.4.2-1 Taiwan's greenhouse gas emissions from industrial processes and product use sectors from 1990 to 2019.....55
Table 2.4.3-1 Greenhouse gas emissions by agriculture sector in Taiwan from 1990 to 2019.....57
Table 2.4.4-1 Land Use, Land Use Change, and Greenhouse Gas Emissions from the Forestry Sector, Taiwan, 1990-2019.....59
Table 2.4.5-1 Taiwan's greenhouse gas emissions by the waste sector from 1990 to 2019.....61
Table 3.3.1-1:Basic principles of the "National Climate Change Action Guideline".....77
Table 3.3.2-1: National and sector-specific greenhouse gas regulatory goals.....79
Table 3.3.3-1: Progress of implementing the assessment indicators for the energy sector.....81
Table 3.3.3-2: Progress of implementing the assessment indicators for the manufacturing sector.....82
Table 3.3.3-3: Progress of implementing the assessment indicators for the transportation sector.....83

Table 3.3.3-4: Progress of implementing the assessment indicators for the residential and commercial sector 85
Table 3.3.3-5: Progress of implementing the assessment indicators for the agricultural sector 87
Table 3.3.3-6: Progress of implementing the assessment indicators for the environmental sector 87
Table 3.3.3-7: Summary of Greenhouse Gas Reduction Policies 88
Table 4.1.1-1: Description of the defined scope 97
Table 4.2-1: The GHG net emission pathway under the "With Existing Measures' Scenario" 97
Table 4.3.1-1: Prediction of Taiwan's economic growth rate and the percentage for the three types of industries 99
Table 4.3.1-2: Operating life of nuclear power generation units 101
Table 4.3.1-3: Volume of natural gas planned 101
Table 4.3.1-4: Volume of natural gas planned 101
Table 4.3.1-5: Power generation from renewable energy 102
Table 5.1.1-1: Average temperature increase in Taiwan from 1907 to 2017 110
Table 7.2-1: International Human Resources Training Workshop Program conducted in 2021 154
Table 8.1-1: Climate change related issues and their connotations in the 12-Year Basic Education of Taiwan 165

List of figures

Figure 1: Percentage of greenhouse gas emissions by type in 2019 09
Figure 2: Trend of total greenhouse gas emissions and removals in Taiwan from 1990 to 2019 09
Figure 3: Trends in greenhouse gas emissions by sector in Taiwan from 1990 to 2019 10
Figure 4: Net greenhouse gas emissions pathway.....11
Figure 5: Division of the Adaptation Strategy to Climate Change by Ministry and Department.....13
Figure 1.1-1: The current organizations the central government of Taiwan.....18
Figure 1.1-2: Counties and cities of Taiwan.....19
Figure 1.2-1: Overall population development trend in Taiwan.....19
Figure 1.3-1: Topographic map of the main island of Taiwan 20
Figure 1.3-2: Use of urban land and non-urban land (national parkland) in Taiwan.....21
Figure 1.4-1: Annual average temperature change in Taiwan.....21
Figure 1.6-1: Power generation structure of Taipower's system in 2020 23
Figure 1.10-1: Types of forest in Taiwan.....31
Figure 2.1-1 National Greenhouse Gas Inventory Preparation Procedure.....34
Figure 2.2-1 Trend of total greenhouse gas emissions and removals in Taiwan from 1990 to 2019 37
Figure 2.3-1 Percentage of greenhouse gas emissions in 2019 for various gases 39
Figure 2.3.1-1 Trend of Taiwan's CO_2 emissions from 1990 to 2019.....40
Figure 2.3.2-1 Trend of Taiwan's methane emissions from 2001 to 2019 42
Figure 2.3.3-1 Trend of Taiwan's nitrous oxide emissions from 1990 to 2019.....44
Figure 2.3.4-1 Trend of Taiwan's hydrofluorocarbons emissions from 1993 to 2019.....45
Figure 2.3.5-1 Trend of Taiwan's perfluorocarbons emissions from 1990 to 2019.....46
Figure 2.3.6-1 Trend of Taiwan's sulfur hexafluoride emissions from 1999 to 2019 47
Figure 2.3.7-1 Trend of Taiwan's nitrogen trifluoride emissions from 1999 to 2019.....48
Figure 2.4-1 Trends in greenhouse gas emissions by sector in Taiwan from 1990 to 2019.....50
Figure 2.4.1-1 Trends in greenhouse gas emissions by energy sector in Taiwan from 1990 to 2019 52
Figure 2.4.2-1Trends in greenhouse gas emissions from industrial processes and product use sectors in Taiwan from 1990 to 2019.....54
Figure 2.4.3-1 Trends in greenhouse gas emissions by agriculture sector in Taiwan from 1990 to 2019 57

Figure 2.4.4-1 Trends in land use, land use change, and carbon removal in the forestry sector in Taiwan from 1990 to 2019 59
Figure 2.4.5-1 Trends in greenhouse gas emissions by waste sector in Taiwan from 1990 to 2019 60
Figure 3.2.1-1: Organizational structure of the National Council for Sustainable Development 66
Figure 3.2.1-2: Organizational structure of the Office of Energy and Carbon Reduction 67
Figure 3.2.1-3: Division of work of various ministries and departments based on the Greenhouse Gas Management Act 69
Figure 3.2.2-1: Structure of Greenhouse Gas Reduction and Management Act 70
Figure 3.2.2-2: Targets that require greenhouse gas emission inventory and registration over the years 71
Figure 3.2.2-3: Certification process of verification bodies in Taiwan 72
Figure 3.2.2-4: Amount of greenhouse gas offset by various sources 73
Figure 3.3-1 Hierarchical promotion structure for the central and local governments regulated by the Greenhouse Gas Management Act 75
Figure 3.3.1-1 : Framework of the National Climate Change Action Guideline 76
Figure 3.3.2-1 : Framework of the Greenhouse Gas Reduction Action Plan 78
Figure 3.3.2-2: Taiwan's greenhouse gas reduction roadmap 79
Figure 3.3.2-3 : Strategies for six major sectors based on the "Climate Change Action Guideline" 80
Figure 3.3.2-4: Eight major supporting measures based on the "Climate Change Action Guideline" 80
Figure 3.3.4-1: Content of the implementation plans 89
Figure 3.3.4-2: Highlights of the greenhouse gas control implementation plans of the local governments 91
Figure 3.3.5-1: Organizational structure of the "Net-Zero Pathway Task Force" 92
Figure 3.3.5-2: progress of social dialogue conducted by the "Net-Zero Pathway Task Force" 93
Figure 4.2-1: Comparison of the pathways of net greenhouse gas emissions 98
Figure 4.3-1: Greenhouse gas emission pathway prediction process 98
Figure 4.3.1-1: Trend of total population growth (under the scenarios of low, medium, and high projection) 100
Figure 4.3.1-2: Power generation structure pathways of various power plants 100
Figure 4.3.2-1: Structure of the TISMO integrated model 103
Figure 4.3.2-2: GEMTEE policy analysis module for agriculture sector 104
Figure 4.3.2-3: GEMTEE database structure of the agricultural sector 105

Figure 5.1.1-1: Observation of temperature in Taiwan from 1911 to 2020 109
Figure 5.1.1-2: Observation of temperature in Taiwan from 1911 to 2017 109
Figure 5.1.1-3: Distribution map of predicted trends of future temperature models in Taiwan 110
Figure 5.1.1-4: Projection of future seasonal length in Taiwan 111
Figure 5.1.3-1: Observation of rainfall in Taiwan from 1911 to 2020 112
Figure 5.1.3-2: Prediction of future rainfall trend in Taiwan 113
Figure 5.1.4-1: Number of typhoons in Taiwan from 1950 to 2014.....114
Figure 5.1.4-2: Number of days with extremely high temperature in Taiwan from 1951 to 2014.....115
Figure 5.1.4-3: Prediction of extremely high temperature trend in Taiwan in the future 115
Figure 5.1.4-4: Number of days with heavy rain, extremely heavy rain and heavy precipitation in Taiwan from 1910 to 2013 116
Figure 5.1.4-5: Number of days with extremely heavy rain in Taiwan from 1999 and 2099 117
Figure 5.1.4-6: Illustration of CMIP6 Warming Scenario 118
Figure 5.3.1-1: Division of work for National Climate Change Adoption Action Plan in Taiwan.....122
Figure 6.1-1: Latest issue of Taiwan's "Strategic Blueprint for Science and Technology Development"134
Figure 6.2-1: Map of observation stations of the Central Weather Bureau, MOTC 140
Figure 6.2-2: Various satellite derivatives produced by geostationary and polar-orbiting satellites.....141
Figure 6.2-3: Taiwan weather radar observation network 141
Figure 6.2-4: Taiwan marine weather monitoring network 142
Figure 6.2-5: Taiwan Climate Services Partnership held its 1st General Meeting on August 20, 2021.....145
Figure 7.2.1-1: The "Home Energy Efficiency and Renewable Energy Project in the Marshall Islands" conducted by the International Cooperation and Development Fund in the Marshall Islands; the members of the project hold a briefing to promote the Home Energy Efficiency and Renewable Energy Project 151
Figure 7.2.1-2: The "Home Energy Efficiency and Renewable Energy Project in the Marshall Islands" conducted by the International Cooperation and Development Fund in the Marshall Islands; Marshall Energy Company staffs visit homes to carry out energy audits 151
Figure 7.2.1-3: The "Solar PV Mini-Grid System for Lighting in Myanmar Rural Areas" project conducted by the International Cooperation and Development Fund in Myanmar; the villagers and the work team celebrate the completion of the power supply station 153
Figure 7.2.1-4: The "Enhancing Agricultural Adaptive Capacity to Climate Variability Project" conducted by the International Cooperation and Development Fund in Saint Kitts and Nevis; a

field demonstration is carried out to explain how to use agrometeorological data for cultivation management and decision-making.....154
Figure 7.2.3-1: The "Workshop on Circular Agriculture Promotion (exclusive for Asia Pacific)" conducted by the International Cooperation and Development Fund; attendees visit the field application of biocarbon.....155

Figure 8.1.1-1: Operation of Climate Change Adaptation Education Teaching Alliance.....167
Figure 8.1.1-2: The 4th SDGs Ecological Urban-Rural Planning and Practice Workshop.....168
Figure 8.1.1-3: Living laboratory "Irrigation and Drainage Engineering" course for teaching alliance in water resources.....168
Figure 8.1.1-4: "The Perspective," Gold Award in the Climate Change Innovation Competition.....169
Figure 8.1.3-1: Education Promotion Framework of the Ministry of Education.....170
Figure 8.3.1-1: "Net-Zero Pathway Task Force" Social Vision Dialogue.....175
Figure 8.3.1-2: "Energy White Paper" citizen engagement workshop in the third stage.....176
Figure 8.3.1-3: Visualization of policy information in the "climate talks.tw" platform.....177
Figure 8.3.2-1: President and Vice President attend Earth Day activities.....178
Figure 8.3.2-2: Well-known buildings in Taiwan participate in the "Earth Hour" event.....178
Figure 8.3.2-3: Youth Anti Global Warm Parade.....179
Figure 8.3.2-4: The 2nd "RE10x10 Green Power Forum".....179
Figure 8.3.2-5: The inaugural meeting of the Taiwan Alliance for Net Zero Emission.....180
Figure 8.3.2-6: Youth and National Climate Vision Forum.....180
Figure 8.3.2-7: CITI Empowers Taiwan Youth to Tackle Climate Change.....181
Figure 8.3.2-8: "Climate leader for future" program promotes climate change education in schools at all levels.....181

Executive Summary

Taiwan has always participated in combating global warming and climate change. In 2015, Taiwan enacted the "Greenhouse Gas Reduction and Management Act (hereinafter referred to as the Greenhouse Gas Management Act)," which legislates a 50% emission reduction target compare to 2005 Greenhouse levels by 2050 as the national long-term reduction target, and sets periodic goals every 5 years.

President Tsai Ing-wen declared on Earth Day on April 22, 2021: "The net-zero by 2050 is not only the goal of the world, but also the goal of Taiwan." On August 30 of the same year, Premier Su Tseng-chang announced the amendment of the "Greenhouse Gas Reduction and Management Act" to form the "Climate Change Response Act," including the "Goal of Net-Zero Emissions by 2050," while presiding over the meeting of the National Council for Sustainable Development. In addition, the Executive Yuan has coordinated with related ministries and departments to set up a "Net-Zero Pathway Task Force" to carry out a net-zero emission roadmap assessment and planning based on the five major work spheres of "Decarbonized Energy," "Industry and Energy Efficiency," "Green Transport and Electrification of Transportation Vehicles," "Negative Emissions Technologies" and "Governance."

Taiwan voluntarily follows the Paris Agreement and made the commitment to officially incorporate the goal of net-zero emissions by 2050 into law. It also follows the spirit of the United Nations Framework Convention on Climate Change (UNFCCC), which requires UN parties to regularly disclose their climate policies and measurements and progress toward the targets. Taiwan has submitted the 2002 and 2011 editions of the National Communication successively, and issued the "2018 National Communications of the Republic of China (Taiwan) under the United Nations Framework Convention on Climate Change" in accordance with the Greenhouse Gas Management Act, fulfilling the requirement to prepare a National Communication every three years and establishing the specifications and chapter structure for the "National Communication" to complete the "2021 National Communications of the Republic of China (Taiwan) under the United Nations Framework Convention on Climate Change," which includes 8 Chapters, namely "National Conditions and Basic Environmental Information," "Statistics and Trend Analysis of Greenhouse Gas Emissions and Absorption," "Greenhouse Gas Reduction Policies and Measures," "Greenhouse Gas Emission Prediction," "Impacts of Climate Change and Adaptation Measures," "Climate Change Scientific Research and Observations," "International Collaboration and Exchanges," and "Education, Training and Communication with the Public." The highlights of each chapter are summarized as follows:

Chapter 1 National Conditions and Basic Environmental Information

Taiwan is located at the junction of East Asia and Southeast Asia and is surrounded by the sea. The terrain is mainly composed of mountains, hills, basins, tablelands, and plains. Mountains account for about two-thirds of the island's total area, with a forest coverage of 60.71%, which is 2 times the global average. The annual average temperature is 24.6°C, and the average annual rainfall is 1,742.4 millimeters (mm).

In terms of population, the total population as of the end of 2020 is approximately 23.56 million, most of which are concentrated in municipalities, accounting for 69.45% of the total population. Owing to population aging and the impact of the COVID-19 pandemic, Taiwan started its negative population growth in 2020. With regard to economic development, the economic growth rate in 2020 reached 3.12%, a record high in the past three years.

The main source of the overall energy supply comes from fossil-fuels. In 2020, petroleum accounted for 44.17%, coal accounted for 30.00%, natural gas accounted for 17.17%; nuclear power generation accounted for 6.57%; biomass energy and waste accounted for 1.21%; hydropower accounted for 0.21%; solar photovoltaic, geothermal, and wind power together accounted for 0.59%; and solar thermal energy accounted for 0.08% of the total energy supply. The energy consumption was 8,540 kiloliters (kl) of oil equivalent, a 0.46% increase from 2019 or an 11.13% increase from 2005.

Chapter 2 Statistics and Trend Analysis of Greenhouse Gas Emissions and Absorption

The statistics on Taiwan's greenhouse gas emissions cover carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). Among the seven greenhouse gases, CO_2 accounts for the greatest amount of greenhouse gas emissions. Its emission in 2019 was 273.515 million tons of CO_2e (excluding LULUCF), accounting for 95.28% of the total greenhouse gases. The CO_2 emissions from fuel combustion accounted for 90.13% of the total CO_2 as shown in Figure 1.

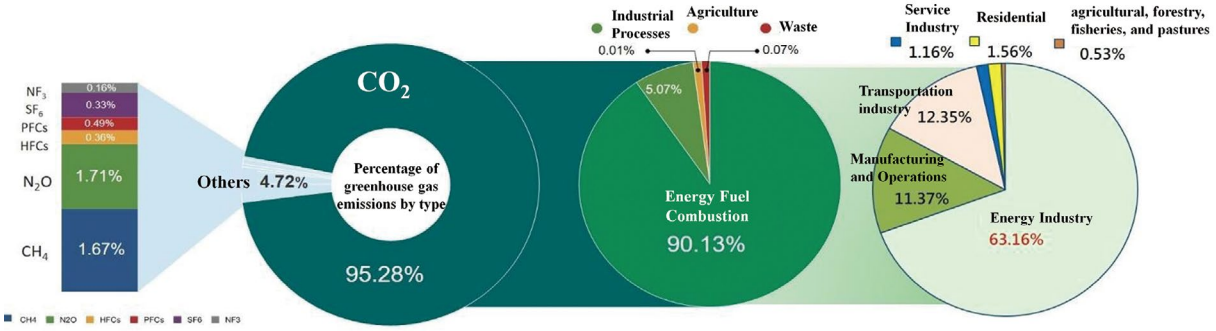

Figure 1: Percentage of greenhouse gas emissions by type in 2019

Taiwan's total greenhouse gas emissions in 2019 were 287.060 million tons of carbon dioxide equivalent (CO_2e), an increase of 108.35% compared to 1990 (137.776 million tons of CO_2e), and an average annual growth rate of 2.56%. Compared to 2005 (290.552 million tons of CO_2e), the total greenhouse gas emissions decreased by 1.20%, with an average annual growth rate of -0.16% as shown in Figure 2.

In terms of the type of gases, carbon dioxide is the largest greenhouse gas produced in Taiwan, followed by methane. The trends of greenhouse gas emissions in various sectors in Taiwan from 1990 to 2019 are shown in Figure 3.

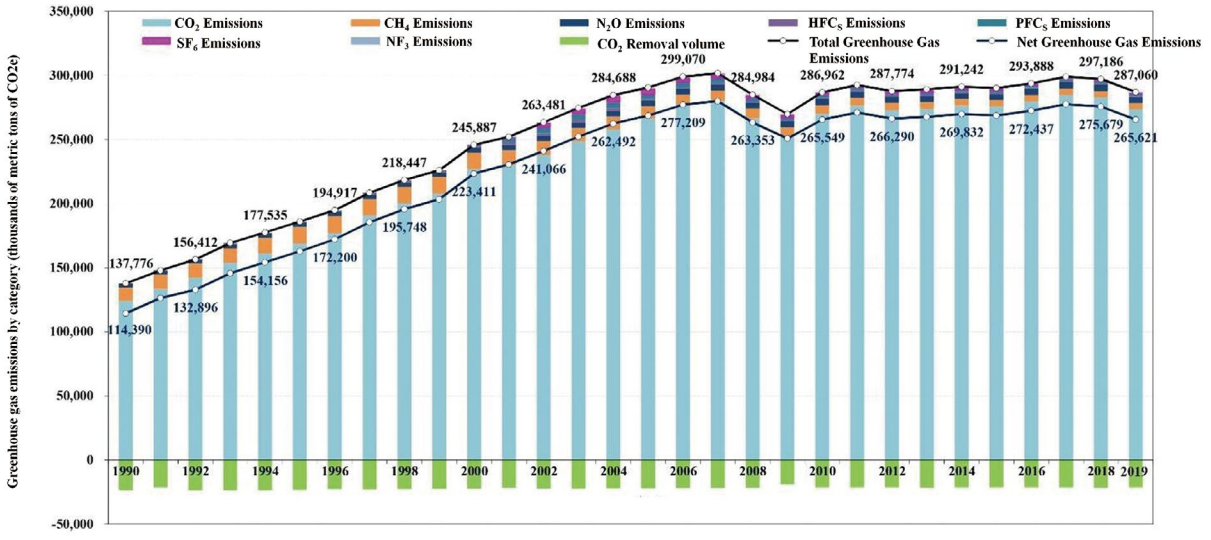

Figure 2: Trend of total greenhouse gas emissions and removals in Taiwan from 1990 to 2019

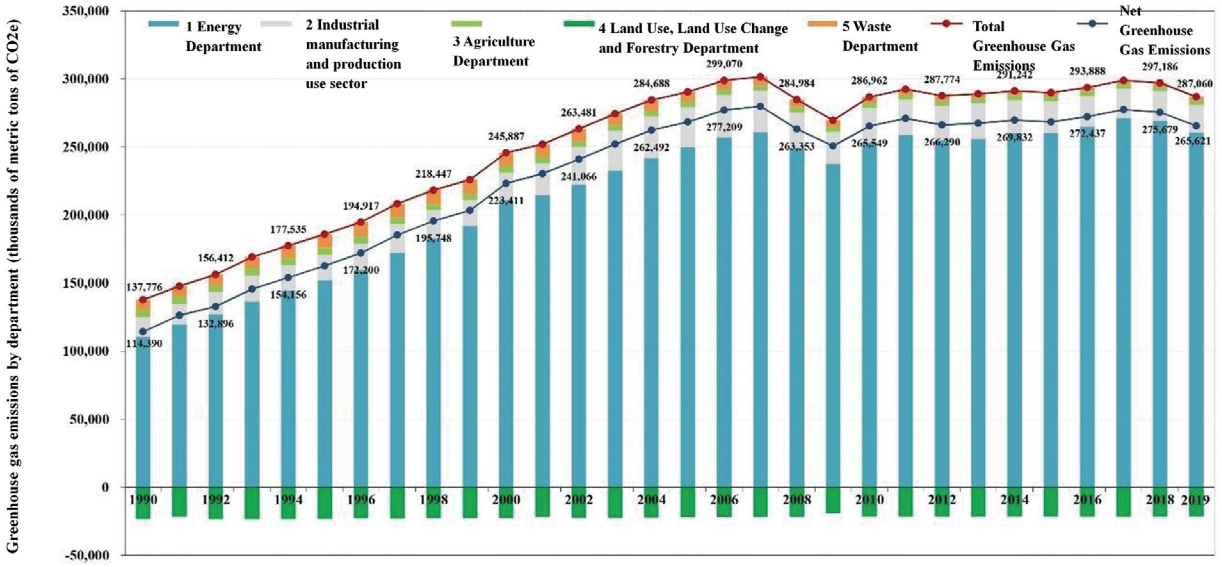

Figure 3: Trends in greenhouse gas emissions by sector in Taiwan from 1990 to 2019

Chapter 3 Greenhouse Gas Reduction Policies and Measures in Taiwan

Climate change is a cross-regional and cross-domain issue. The promotion of climate policies highly relies on the coordination between various ministries and departments, as well as the collaboration between central and local governments. In order to establish a sound climate governance framework and reduction measures, and actively promote international collaboration, the Executive Yuan coordinated and established the "Climate Change and Carbon Reduction Task Force" and the "Office of Energy and Carbon Reduction" under the National Council for Sustainable Development. The Office of Energy and Carbon Reduction is responsible for convening the "Net-Zero Pathway Task Force."

Regarding regulations and policies, the Greenhouse Gas Management Act is adopted as the framework for coordinating Taiwan's climate action. The Greenhouse Gas Management Act clearly sets the national long-term target for the reduction of greenhouse gases, and for related ministries/departments to develop a national-level "Climate Change Action Guideline" and "Greenhouse Gas Reduction Action Plan."

The content of the Action Plan comprises periodic regulatory goals, and reduction policies as well as the supporting measures and its indicators of effectiveness for the energy sector, manufacturing sector, transportation sector, residential and commercial sector, agricultural sector, and environmental sector. The key actions and achievements of each sector in 2020 are summarized as follows:

Energy sector: Construct a low-carbon energy supply system and promote energy transformation to increase the percentage of renewable energy generation to 20% by 2025. Greatly increase the installation of renewable energy, including solar photovoltaic and wind power generation. Improve the LNG unloading capacity to increase the percentage of natural gas power generation to 50% by 2025.

Manufacturing sector: Strengthen the carbon reduction actions in industries, implement industrial transformation, and promote sustainable production processes. Reach the goal of decreasing the carbon intensity target of the manufacturing sector to 43% of the 2005 levels by 2020, ahead of schedule.

Transportation sector: Continue to increase the volume of public transportation. The volume of public transportation increased by at least 7% in 2020 compared to 2015, slowing down and reducing the use of private transportation. It is expected that the "newly purchased official vehicles and public buses will be fully electric by 2030."

Residential and commercial sector: Enhance the energy efficiency benchmarks for new building construction design, strengthen the reduction management of existing buildings, and plan to build the carbon reduction capabilities of the competent authorities in the service sector. On August 19, 2019, the "Building Technical Regulations" were amended,

and the "Technical Code for Energy Conservation Design of Buildings" was implemented in 2021. It is expected that the energy efficiency benchmarks for new buildings can be increased by 5%.

Agricultural sector: Measures such as government acquisition of fishing boats and rafts, fishing moratorium rewards, subsidies for the expansion of organic and environmentally-friendly farming areas to 15,000 hectares, subsidy and acquisition policies for land and green environment, the reuse of livestock farm biogas (for power generation), policies of maintaining and ensuring the self-sufficiency of domestic livestock and poultry products, and completing afforestation with area of 3,636 hectares were implemented.

Environmental sector: When formulating policies and implementing environmental impact assessments, specific actions for resilience building and emissions mitigation should be considered, including implementing energy and resource recycling, creating a shared economic society by enhancing the reuse of regional energy resources, and reducing the emission of greenhouse gases during the treatment of waste and wastewater (sewage). Last but not least, increase the sewage treatment rate in Taiwan to 60.8% by 2020.

In response to the global trend of promoting net-zero emissions, the Office of Energy and Carbon Reduction initiated the assessment for Taiwan's net-zero emissions pathway and invited relevant ministries and departments to establish a "Net-Zero Pathway Task Force," which includes three mechanisms (five major work spheres, the model group, and the vision group) and five supporting policies for the transition (social system, green funds, behavior change, equitable transformation, and international collaboration), conducting studies on model simulation and scenario analysis related to net-zero emissions.

Taiwan has announced on October 21, 2021 that the "Greenhouse Gas Reduction and Management Act" will be amended to form the "Climate Change Response Act," which will include new regulations for the collection of carbon fees. Furthermore, it took the initiative to promote other energy and environment-related policies, such as the Electricity Act, the Renewable Energy Development Act, and the Energy Tax Act (draft), providing more comprehensive regulatory instruments and economic incentives for climate actions.

Chapter 4 Greenhouse Gas Emission Prediction

With the long-term reduction targets set by the Greenhouse Gas Management Act, and based on the mitigation potential of the energy-saving and carbon-reduction strategies of various sectors, the national and individual sectors of greenhouse gas emissions pathways were predicted. Periodic regulatory goals are set every 5 years to gradually promote the implementation of reduction policies.

Taiwan's greenhouse gas emissions pathways from 2020 to 2035 are based on the "Phase II Periodic Regulatory Goals" approved on September 29, 2021. In addition, the energy consumption and greenhouse gas emissions of each sector are estimated by their corresponding competent authority based on the unified parameter

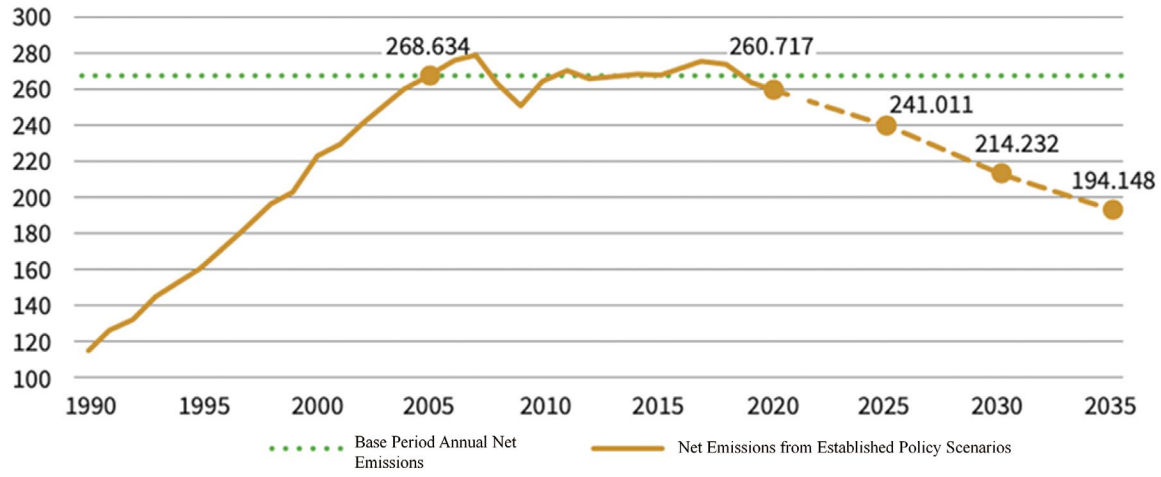

Figure 4: Net greenhouse gas emissions pathway

assumptions (economic growth, population) and the combined pathways. It includes the prediction pathways of fuel combustion emissions, non-fuel combustion emissions, and carbon sinks for the six major sectors. In order to take into consideration the "With Policy Measure" during the planning of carbon reduction policies, the effectiveness of Taiwan's greenhouse gas reduction was evaluated under the "With Existing Measures' Scenario."

Under the "With Existing Measures' Scenario" and using 2005 as the base year, all the policies and measures that have been implemented and passed in Taiwan are expected to reduce greenhouse gas emissions by 2% in 2020, 10% in 2025, 20% in 2030, and 25-30% in 2035, so that the statutory target of 50% reduction by 2050 can be achieved. The information is shown in Figure 4.

Chapter 5 Impacts of Climate Change and Adaptation Measures

Affected by terrain, typhoons, and frequent natural disasters such as floods and landslides, as well as the increasing occurrence of extreme weather in the future due to global climate change, Taiwan will face more threats. To respond to the impact of climate change in advance, Taiwan adopted the specifications of the IPCC Fifth Assessment Report (AR5), which defines the "risk" of climate change as a function of "hazard," "exposure" and "vulnerability" for assessment, and refined relevant policies and measures based on the assessment results.

In order to enhance Taiwan's ability to cope with climate change, after passing the "Greenhouse Gas Reduction and Management Act" in 2015, the "National Climate Change Action Guideline" was proposed, serving as the overall framework for Taiwan to promote adaptation actions. In addition, Taiwan continues to revise the related provisions of the "Spatial Planning Act," the "Coastal Zone Management Act," the "Wetland Conservation Act" and the "Water Act" to promote and review the "National Climate Change."

With regards to finance, in order to adapt to the needs of climate change, government financial balance plans and green financial measures were promoted to bring about diversified financial sources. For example, damage to residential buildings caused by disasters such as typhoons or floods in Taiwan being covered by resident insurance starting from 2020. In addition, Taiwan also encourages businesses to develop commercial-based agricultural insurance, green insurance, and issuance of green bonds to assist farmers and fishermen in reducing climate risks and provide multiple financing channels for the public, guiding funds to invest in environmentally-friendly applications. Moreover, the Taiwan Academy of Banking and Finance continues to conduct professional research and training to assist the financial industry in improving the quality of credit and the capability to undertake green energy financing. The government is also studying other fiscal and financial tools related to climate change and seeking the possibility of integrating them into the existing fiscal and financial regulations during the amendment procedures of the Greenhouse Gas Management Act.

In addition, to complete the scientific research and knowledge of the adaptation strategy, the Ministry of Science and Technology promotes the localization of climate change prediction information, strengthens the connection between scientific research and policy, and incorporates the research results into the Climate Change Integration Service Platform to build a national marine weather, hydrology, ecology, and coastal land change monitoring network, enhancing the national marine adaptation strategy and disaster response capabilities. It includes a comprehensive and real-time national marine hydrology, ecology, and land monitoring network to carry out fundamental and long-term studies, helping the sea area of Taiwan with scientific data and technology to engage in the development of smart agriculture (fishing) industry, renewable energy, marine adaptation strategies, and homeland security, thereby cultivating national disaster response capability to cope with the intensified challenges created by climate change. As for technology and implementation, various innovative waste treatment technologies will be developed through government-industry-university-institute collaborations. Various "optimal and feasible control technologies" will be developed, and management methods, as well as standards for bringing waste into the cycle, will be established to improve resource use efficiency. The information is shown in Figure 5.

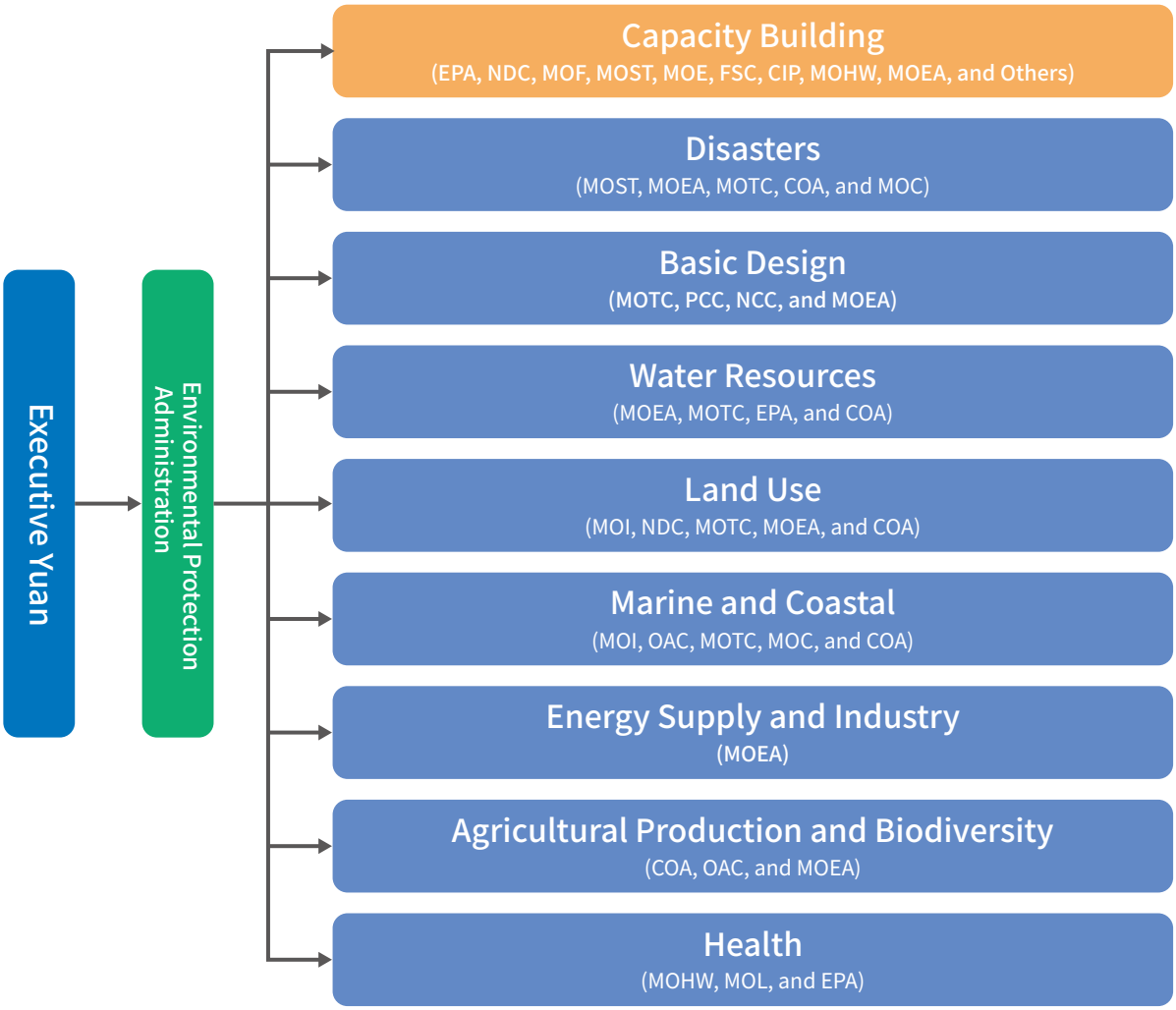

Figure 5: Division of the Adaptation Strategy to Climate Change by Ministry and Department

Chapter 6 Climate Change Scientific Research and Observations

The Ministry of Science and Technology is the central competent authority for scientific research and technology development in Taiwan. It coordinates plans and strategies for Taiwan's overall scientific and technological development, including climate-change related scientific research. In addition, the Ministry of Science and Technology also promotes cross-domain integrated research projects, builds the key capabilities for climate simulation, prediction, and interpretation, and participates in the implementation of climate-change related policies for various ministries and departments.

The promotion and management mechanism of the Taiwan's climate-change related scientific research is based on the provisions of the "Fundamental Science and Technology Act," that the Executive Yuan convenes the "National Science and Technology Conference" every four years, which serves as an important platform for the nation to coordinate science and technology policies. During the 6th National Science and Technology Conference in 2020, climate change issues were incorporated into the science and technology development policies.

The Ministry of Science and Technology has been engaging in climate science services since 2017. Through the "Taiwan Climate Change Projection Information and Adaptation Knowledge Platform (TCCIP)," climate scenarios, risk information, and adaptation tools are integrated, allowing the

government, industries, research institutions, or the public to implement scientific research applications.

Meteorological observations can be roughly divided into surface meteorological observations, upper-air meteorological observations, and special meteorological observations due to differences in the scope, items, purposes, and methods of observation. To strengthen weather monitoring and forecasting technologies, and serve as a reference for the formulation of climate change risk management and adaptation policies, the government has established a five-year disaster action plan, which includes the "Hazardous Weather Monitoring and Forecasting Systems Enhancement Project" and the "Climate Change Application Service Capacity Development Project." Through the implementation of the "Project for Strengthening Taiwan's Marine Weather and Meteorological Environment Monitoring for Disaster Prevention," the monitoring of domestic rainfall and sea area is strengthened.

Chapter 7 International Collaboration and Exchanges

Although Taiwan is not a member of the United Nations, it has always complied with and fulfilled relevant international environmental conventions and norms. Taiwan also actively participates in climate convention-related conferences and promotes exchanges and collaborations with representatives of industries, governments, universities, and research institutes from all over the world, fulfilling its obligations and responsibilities as a member of the global village.

Since 2002, Taiwan has been following the international standards recognized by the UNFCCC and continues to issue and update the "National Communication," the "National Greenhouse Gas Inventory Report," and the "Intended Nationally Determined Contribution (INDC)," implementing international environmental conventions.

I. National level

Taiwan's collaboration and exchanges with international intergovernmental organizations are mainly conducted through the help of the International Cooperation and Development Fund, which has promoted multilateral or bilateral financial collaboration, technical cooperation, and capacity building, assisting diplomatic allies or other friendly countries in developing their economy, social and human resources, and providing humanitarian aid or assistance to international refugees fleeing from natural disasters.

II. Local government level

A total of 11 cities in Taiwan have joined the International Council for Local Environmental Initiatives (ICLEI), Local Governments for Sustainability. Currently, Kaohsiung City has established the "ICLEI Kaohsiung Capacity Center (ICLEI KCC), serving as the East Asia operations center to perform the tasks assigned by the ICLEI World Secretariat and offer support to various offices in East Asia, providing member training, professional knowledge, and information exchange on the management of various environmental sustainability policies.

III. Non-governmental organizations

Regarding international initiatives, more than a hundred companies in Taiwan have joined RE100 and have made a public commitment to achieve the use of 100% renewable energy by 2020-2050, and to report their progress year on year. Among them, companies in the semiconductor and electronics field have also joined EV100, hoping to reduce carbon emissions by increasing the use of renewable energy as well as the infrastructure of electric vehicle charging stations and services. Others such as the energy productivity improvement initiative (EP100), the transparency initiative (Task Force on Climate-related Financial Disclosures (TCFD), Climate Action 100+), and the Science Based Targets Initiative (SBTi) have all been joined onto by many companies in the financial industry, the biotechnology industry, and investment institutions.

In addition, there are academic research organizations and civic groups in Taiwan that are actively participating in climate convention-related conferences, focusing on international carbon pricing trends, carbon capture, and storage technology, etc. to demonstrate their diverse and autonomous capabilities in civil society participation.

Chapter 8 Education, Training and Communication with the Public

In response to the requirements of Article 6 of the Convention for the promotion of climate change education, training and public awareness, the

government has incorporated those requirements into the education system. Climate change education in Taiwan is divided into two major directions: climate change mitigation education and adaptation education. Its legal basis includes the "Greenhouse Gas Management Act" and the "Basic Environment Act"; the "Adaptation Strategy to Climate Change" in Taiwan is used as the policy basis for the adaptation of education.

As to mitigation education, a school carbon inventory is promoted to allow students to understand greenhouse gas emissions generated by school activities so that further mitigation plans can be proposed. In addition, collaboration with the government, industries, universities and research institutes for mitigation and energy technologies are carried out to increase students' opportunities in practical participation.

With regard to the adaptation of education, school adaptation actions are promoted. Colleges and universities can prioritize the areas for adaptation according to the climate and environmental phenomenon of their campuses, and their living labs or cross-domain teaching methods.

In terms of social dialogue and public participation, the government launched a Net-Zero Pathway Task Force in 2020 to gather all walks of life in discussing the key technologies or issues of net-zero emissions and the formulation of the Energy White Paper. By increasing public participation for planning future energy policies and establishing the "Climate Talks" platform, interactive policy information and calling for online opinions can be made possible. By promoting low-carbon sustainable communities, the power and resources of the central/local governments, and private enterprises can be integrated, starting from small participation units such as communities in townships, urban areas, or villages, and gradually expanded to large participation units in big cities.

Finally, with regard to the promotion of climate empowerment by civic groups, both the government and civic groups have actively responded to international environmental protection actions and promoted initiatives related to corporate sustainable development, such as Earth Day, the RE10x10 initiative, or organizing the Youth and National Climate Vision Forum and corporate-sponsored youth empowerment to bring together resources and lecturers, assisting in the implementation of climate change teaching materials that meet the needs of schools.

Chapter 1

National Conditions and Basic Environmental Information

1.1 Government organization and legislation
1.2 Population
1.3 Geographical location and land use
1.4 Climate
1.5 Economy and industry
1.6 Energy
1.7 Transportation
1.8 Buildings and urban structures
1.9 Waste
1.10 Agriculture, forestry, fishery, and animal husbandry

Chapter 1 National Conditions and Basic Environmental Information

The development and changes in the natural environment and social and economic structure will affect the country's greenhouse gas emission pathway and the impact of climate change. Therefore, this chapter explains the national conditions and the environment of Taiwan from the aspects of government organization and legislation, population profile, geographical location and land use, climate profile, economy and industry, energy, transportation, building and urban structure, waste disposal, and agriculture, forestry, fishery, and animal husbandry.

1.1 Government organization and legislation

I. Central government

In accordance with the Constitution of the Republic of China (hereinafter referred to as the Constitution), the Amendment of the Constitution, and related laws and regulations, the government of Taiwan has established five branches (Yuans), including the Executive Yuan, the Legislative Yuan, the Judicial Yuan, the Examination Yuan, and the Control Yuan, to exercise its powers. According to the Constitution, the President is the head of the country and is directly elected by all the people to a four-year term, with a limit of two terms.

The Executive Yuan is the highest administrative body in the country. The head of the Executive Yuan or Premier is appointed by the President, while the Vice Premier, leaders of various ministries, and councils or commissions are appointed by the President upon request of the Premier. There are 29 organizations under the Executive Yuan, including 14 ministries, eight councils or commissions, three independent agencies, one central bank, one national museum, and two directorate-general offices, as shown in Figure 1.1-1 below.

The Legislative Yuan is the country's highest legislative body, composed of legislators directly elected by the people to exercise legislative power on behalf of the people. The Judicial Yuan is the country's highest judicial body, in charge of the trial of civil, criminal, and administrative litigation as well as the punishment of civil servants. The Examination Yuan is the country's highest examination body. The Control Yuan is the country's highest supervisory body, which exercises the powers of impeachment, censure, and audit.

The Executive Yuan initiated organizational reforms in 2012. The ministries and councils or committees that have yet to be reorganized include the upgrade of the Council of Agriculture to the Ministry of Agriculture, the upgrade of the Environmental Protection Administration to the Ministry of Environment and Natural Resources, the establishment of National Park Administration under the Ministry of the Interior, the reorganization of the Ministry of Transportation and Communications to the Ministry of Transportation and Construction, and the reorganization of the Ministry of Economic Affairs to the Ministry of Economic and Energy Affairs. In addition, new ministries and councils or commissions will be established. On March 25, 2021, the Executive Yuan passed 16 organizational reform bills, including the draft amendment of the "Organizational Act of the Executive Yuan" and the "Basic Code Governing Central Administrative Agencies Organizations." It proposed the organizational reform bills for the establishment of the “Ministry of Digital Development,” the reorganization of the "Ministry of Science and Technology" to the “National Science and Technology Council” and the addition of the “All-Out Defense Mobilization Agency” to the Ministry of National Defense to improve organizational effectiveness, industrial development, national power, and national security. Among them, the "Basic Code Governing Central Administrative Agencies Organizations" will be co-signed by the Examination Yuan and sent to the Legislative Yuan for deliberation, while the other 15 bills will be sent to the Legislative Yuan for review.

Ministry of the Interior	Ministry of Foreign Affairs	Ministry of National Defense
National Taxation Bureau	Ministry of Education	Ministry of Justice
Ministry of Economic Affairs	Ministry of Transportation	Ministry of Labor
Council of Agriculture, Executive Yuan	Ministry of Health and Welfare	Environmental Protection Administration, Executive Yuan
Ministry of Culture	Ministry of Science and Technology	National Development Council
Mainland Affairs Council	Financial Supervisory Commission	Ocean Affairs Council
Overseas Community Affairs Council	Veterans Affairs Commission	Council of Indigenous Peoples
Hakka Affairs Council	Public Construction Commission, Executive Yuan	Directorate-General of Budget, Accounting, and Statistics
Directorate-General of Personnel Administration	Central Bank	National Palace Museum
Atomic Energy Council of the Executive Yuan	Central Election Commission	Fair Trade Commission
National Communications Commission	Transitional Justice Commission	

Figure 1.1-1: The current organizations under the central government of Taiwan

Source: Official website of the Executive Yuan

II. Local governments

The "Local Government Act" has been revised several times, and now there are six special municipalities, including Taipei City, New Taipei City, Taoyuan City, Taichung City, Tainan City, and Kaohsiung City. In addition, there are a total of 13 counties and three cities, including Yilan County, Hsinchu County, Miaoli County, Changhua County, Nantou County, Yunlin County, Chiayi County, Pingtung County, Hualien County, Taitung County, Penghu County, Keelung City, Hsinchu City, Chiayi City, Kinmen County, and Lianjiang County, 146 townships, 38 towns, 14 county-controlled cities, and 170 districts.

1.2 Population

The total population of Taiwan as of the end of 2020 was approximately 23.56 million. Most of the population is concentrated in special municipalities, accounting for 69.45% of the total population. Among the special municipalities, New Taipei City has the largest population of 4.03 million, accounting for 17.11% of the total population. In terms of population density, it has an average of 651 people per square kilometer in 2020. Taipei City has the highest population density in Taiwan, with an average population density of 9,575 people per square kilometer.

As to population structure, in 2020, children under the age of 15 accounted for 12.58% of the total population, showing a decreasing trend year by year; teenagers and adults aged 15 to 64 accounted for 71.35% of the total population, dropping from its peak at 74.22% in 2012. The population of elderly people aged 65 years or older is increasing yearly. It has surpassed the population of children under the age of 15 in 2017, accounting for 16.07% of the total population in 2020.

Under the trend of declining birth rates and aging population, the number of deaths in 2020 exceeded the number of births, reaching a natural population decrease. In addition, due to the impact of the COVID-19 pandemic, it is difficult to maintain a positive social increase dominated by international migration to compensate for the natural population decrease. After the total population reached a peak of 23.6 million in 2019, it dropped to 23.56 million, starting a negative population growth.

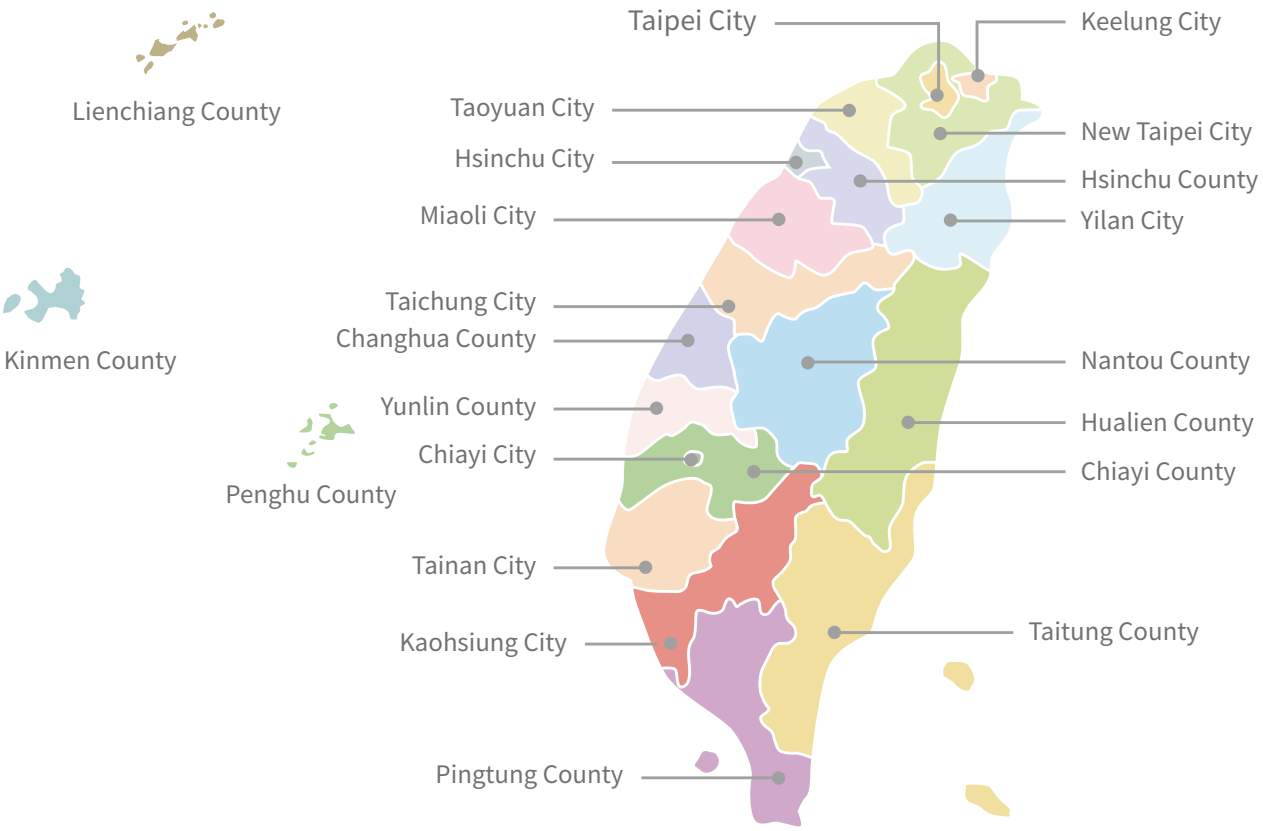

Figure 1.1-2: Counties and cities of Taiwan

Source: Official website of the Ministry of the Interior

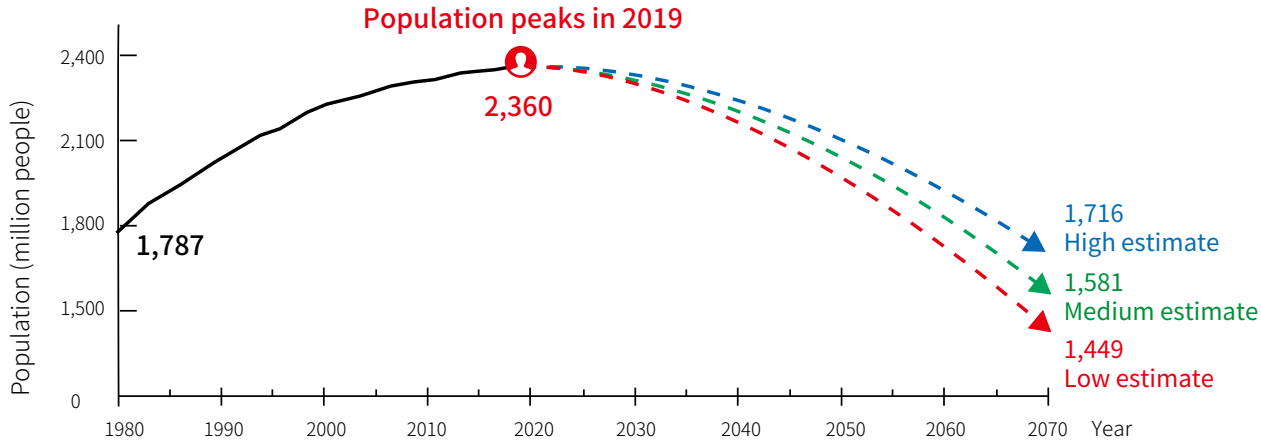

Figure 1.2-1: Overall population development trend in Taiwan

Source: National Development Council, "Population Projections for the R.O.C. (Taiwan): 2020~2070", August 2020

1.3 Geographical location and land use

I. Geographical location

The territories of Taiwan include its main island and its affiliated islands, namely the Penghu Islands, the Kinmen Islands, the Mazu Islands, the Dongsha Islands, and the Nansha Islands, with a total area of 36,179.067 km2. The main island is located between 21 and 26 degrees north latitude, and the Tropic of Cancer (23.5 degrees north latitude) passes through Chiayi County on the southeastern edge of the Asian continental shelf.

The main island is 394 km long from north to south, with a maximum width of 144 km from east to west. The island is surrounded by the sea, with the Pacific Ocean to the east, the Taiwan Strait to the west, and the Bashi Channel to the south. The coastline is 1,139 km long. The terrain is high in the east and low in the west, with mountains, hills, basins, tablelands, and plains as the main landform.

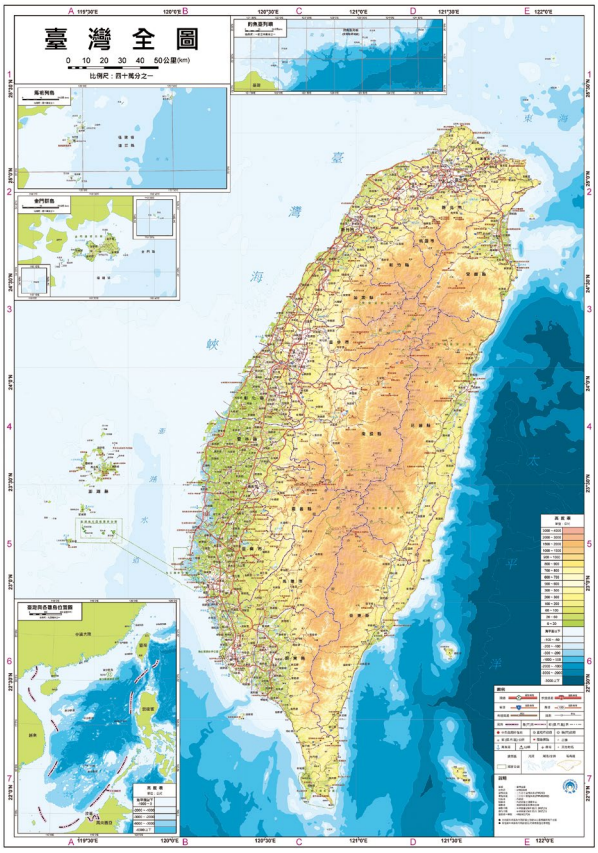

Figure 1.3-1: Topographic map of the main island of Taiwan

Source: Official website of the Executive Yuan

Mountains account for about two-thirds of the island's total area. From east to west, there are five mountains: Coastal Range, Central Range, Hsuehshan Range, Yushan Range, and Alishan Range. The Central Range is steep, forming the spine of the main island and serving as the drainage divide between the east and west rivers. To the west of the Alishan Range is the gradually flattening basin and plain. From north to south are the Taipei Basin, the Taozhumiao (Taoyuan, Hsinchu, and Miaoli) Tableland, the Taichung Basin, the Chianan Plain, and the Pingtung Plain.

II. Land use

With regards to the use of urban land and non-urban land (national parkland) in Taiwan in 2020, urban land is mainly consisted of protected areas (27.8%), agricultural areas (20.7%), and land for public facilities (19%), while the non-urban land mainly consists of forest areas (43.9%), hillside conservation areas (21.9%), and national park areas (9.7%) as shown in Figure 1.3-2.

The land of Taiwan is categorized into three types: urban land, non-urban land, and national parkland. The "Spatial Planning Act" promulgated and implemented in 2016 governs the management. The Ministry of the Interior is currently assisting local governments in checking the functional zone maps, which are expected to be completed before April 30, 2025. According to the characteristics of land resources, the needs of conservation, utilization, and management, the land of Taiwan is divided into four functional zones, including environmental conservation zones, marine resource zones, agricultural development zones, and urban-rural development zones.

1.4 Climate

Taiwan has a subtropical and tropical marine climate and is located in the Asian monsoon region. In winter, it is affected by the northeast monsoon due to the continental cold high pressure, while in summer, it is affected by the southwest monsoon due to the monsoon hot low pressure.

In terms of temperature, the temperature in Taiwan has shown a continuously increasing trend, which is more evident than the global temperature rising trend. 2020 is the warmest year recorded in the history of Taiwan, with an average annual temperature of 24.6°C, which is about 1°C higher than the climatological normal, as shown in Figure 1.4-1.

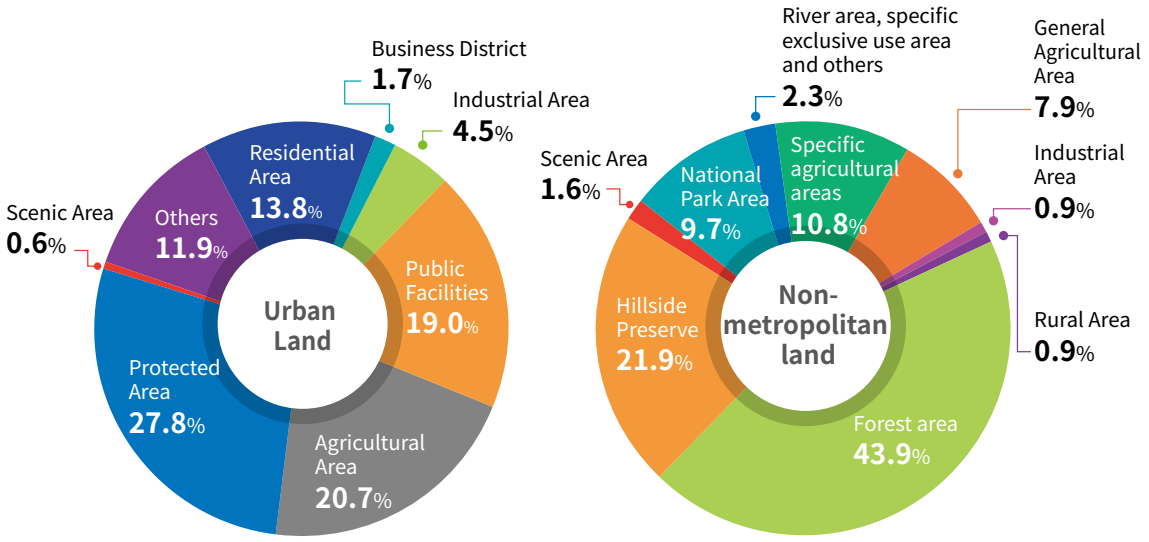

Figure 1.3-2: Use of urban land and non-urban land (national parkland) in Taiwan

Source: National Development Council, "Urban and Regional Development Statistics", 2020

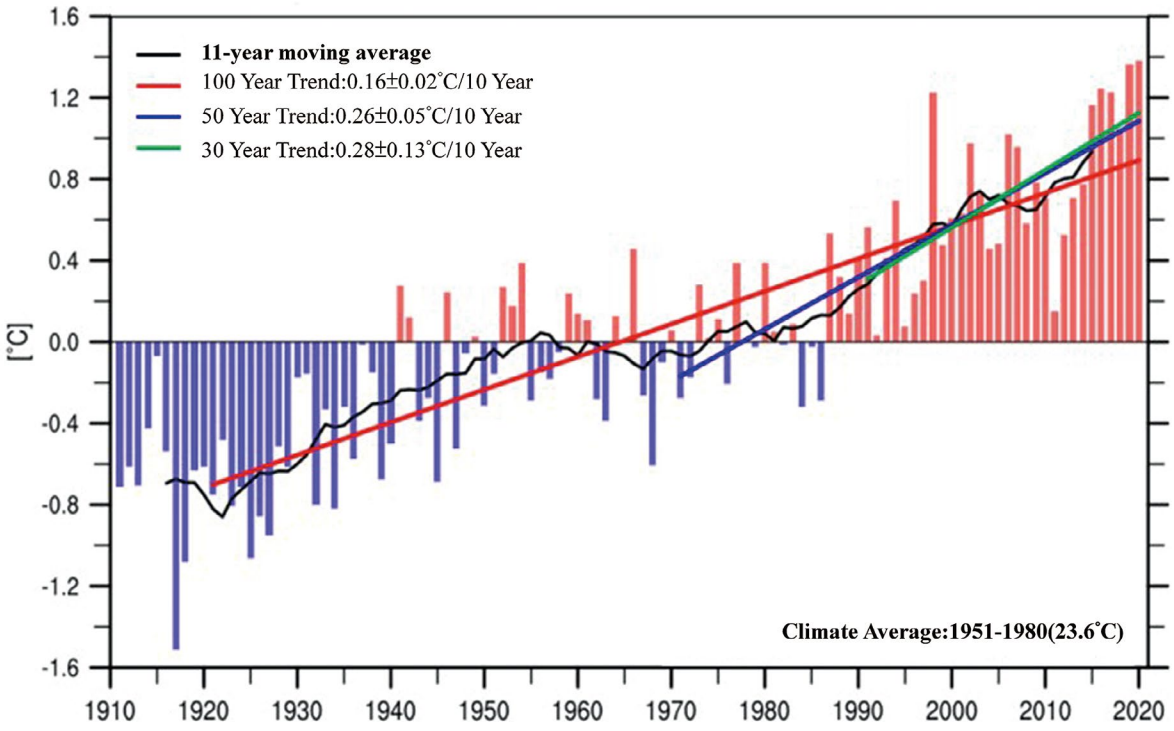

Figure 1.4-1: Annual average temperature change in Taiwan

Source: Official website of the Central Weather Bureau, MOTC

As to rainfall, under the influence of East Asian monsoon circulation, frontal and typhoon weather systems, the primary sources of precipitation in Taiwan include spring rains, plum rains, typhoon rainfall, southwesterly flow rainfall, and northeast monsoon rainfall. The average annual total rainfall in 2020 is 1742.4 mm, 464.7 mm lower than the climatological normal, which is only 78% of the climatological normal (2207.0 mm). It ranks 7th for the year, with the lowest rainfall recorded in the history of Taiwan. Particularly the rainfall in the central mountainous area of Taiwan only accounts for 50%~70% of the climatological normal.

1.5 Economy and industry

In 2020, the economic growth rate of Taiwan reached 3.36%, a record high in the past three years. The economic growth is mainly driven by exports and investment, including the digital and emerging technology business opportunities created by the COVID-19 pandemic and the returning of Taiwan businesses to expand domestic production capacity continuously. In 2019, the GDP per capita increased from US$ 25,941 in 2019 to US$ 28,371. In 2021, domestic production capacity and investment were expanding, while commodity exports and investment performance are better than expected, which continue to boost the economy. The Directorate General of Budget, Accounting and Statistics, Executive Yuan predicts that the economic growth rate in 2021 will reach 4.15%.

Table 1.5-1: Taiwan's economic growth rate from 2005 to 2020

Year	Economic growth rate (%)	Gross domestic product (GDP) (Nominal value, one million NTD)		GDP per capita (Nominal value, NTD)	
		Original value	Annual growth rate (%)	Original value	Annual growth rate (%)
2005	5.38	12,036,675	3.80	529,556	3.42
2006	5.77	12,572,587	4.45	550,863	4.02
2007	6.85	13,363,917	6.29	583,133	5.86
2008	0.80	13,115,096	-1.86	570,279	-2.20
2009	-1.61	12,919,445	-1.49	559,807	-1.84
2010	10.25	14,060,345	8.83	607,596	8.54
2011	3.67	14,262,201	1.44	614,922	1.21
2012	2.22	14,677,765	2.91	630,749	2.57
2013	2.48	15,270,728	4.04	654,142	3.71
2014	4.72	16,258,047	6.47	694,680	6.20
2015	1.47	17,055,080	4.90	726,895	4.64
2016	2.17	17,555,268	2.93	746,526	2.70
2017	3.31	17,983,347	2.44	763,445	2.27
2018	2.79	18,375,022	2.18	779,260	2.07
2019	3.06	18,908,632	2.90	801,348	2.83
2020	3.36	19,766,240	4.71	839,558	4.77

Source: Website of National Statistics, R.O.C. (Taiwan)

In terms of industrial development, to accelerate industrial transformation and upgrade, Taiwan has created a new economic model that pursues sustainable development with "innovation, employment, and distribution" as its core values. It adopts three strategies of "connecting the future, connecting the world, and connecting the local community" to stimulate innovation and energy for the industries. The "The 5+2 Industrial Transformation Plan" was proposed, which includes "Smart Machinery", "Asia Silicon Valley", "Renewable Energy Technology", "Biomedical Industry", "Defense Industry", "New Agriculture" and "Circular Economy", serving as the core for the growth of the next generation industry. Through the development of crucial forward-looking technologies and the recruitment of outstanding talents, the government aims to form industrial innovation clusters to strengthen system integration capabilities and attract domestic/foreign investment, further connecting the global innovation energy to enhance the international competitiveness of Taiwan's industries and the quality of life of the people, so as to realize the Green Silicon Island and Smart Taiwan and achieve the goals of balanced regional development and job creation.

1.6 Energy

The energy development in Taiwan is faced with several inherent constraints, including high dependence on imports, dependence on fossil energy, and isolation of power systems. In recent years, related technologies have been developed rapidly under the global trend of promoting greenhouse gas reduction. Although Taiwan is encountering the pressure of energy transformation, it also regards the crisis as a turning point. In terms of energy supply, Taiwan continues to increase the percentage of renewable energy. As for energy demand, it continues to improve energy efficiency. These measures can reduce Taiwan's dependence on imported fossil energy and enhance its energy security and independence.

I. Energy supply

As to the overall energy supply, fossil fuel-based energy is the majority. In 2020, petroleum accounted for 44.17%, coal accounted for 30.00%, natural gas accounted for 17.17%, nuclear power generation accounted for 6.57%, biomass energy and waste accounted for 1.21%, hydropower accounted for 0.21%, solar photovoltaic, geothermal, and wind power together accounted for 0.59%, and solar thermal energy accounted for 0.08% of the total energy supply.

In terms of the power generation structure of Taipower's system, in 2020, gas-fired power generation has the highest percentage of 40.8%, followed by coal-fired power generation at 36.4%, nuclear energy at 12.7%, renewable energy at 5.8%, and fuel-fired power generation at 1.3% as shown in Figure 1.6-1.

In terms of the total energy supply growth, Taiwan has grown from 134.08 million kiloliters of oil equivalent (KLOE) to 138.48 million kiloliters of oil equivalent (KLOE) from 2005 to 2020, a growth rate of 3.28%. The total energy supply in 2020 shows a downward trend compared with the previous year, with a growth rate of -6.68%. The decline is mainly because Taiwan's oil exports are affected by the COVID-19 pandemic, and the refining volume of domestic oil refineries has declined, and crude oil imports have also decreased, leading to the decrease in the supply of crude oil and petroleum products by 12.14%. In addition, due to the water shortage, hydropower generation in 2020 was reduced by 45.55%. However, as Taiwan continues to promote the energy transformation, the demand for gas-fired power generation has increased the power supply from natural gas by approximately 6.98%, while solar photovoltaic and wind power generation have also soared by 51.84% and 28.58%, respectively, as shown in Figure 1.6-1.

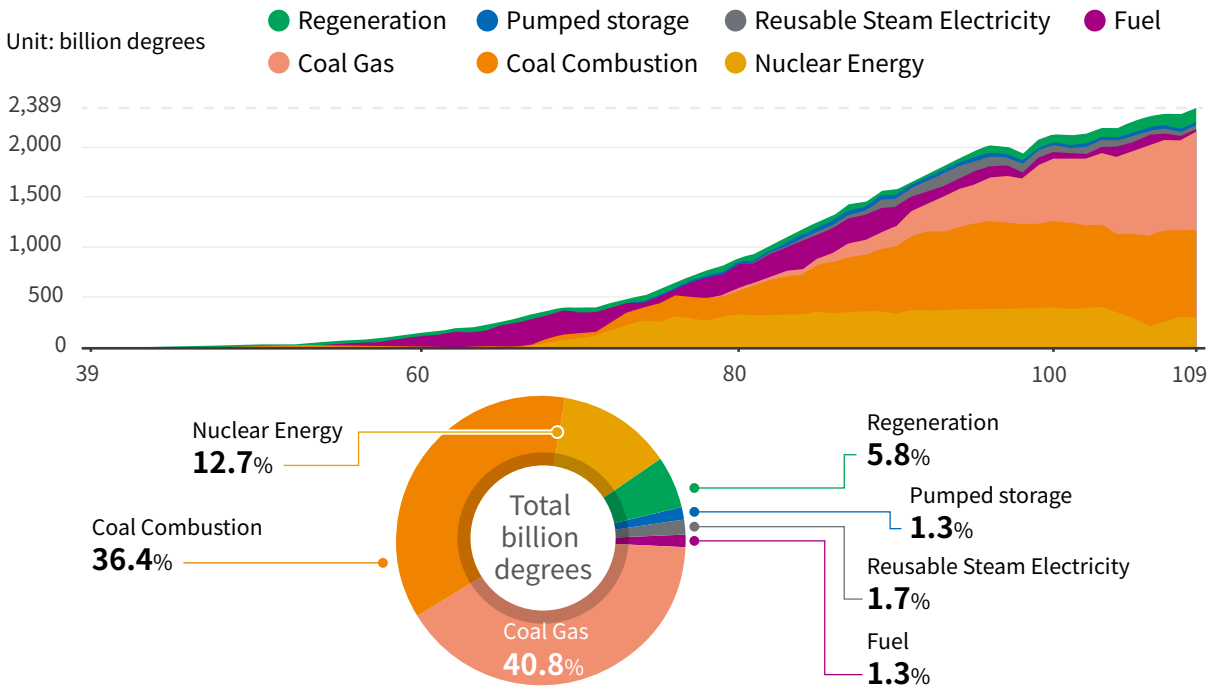

Figure 1.6-1: Power generation structure of Taipower's system in 2020

Source: Official website of the Taiwan Power Company

Table 1.6-1: Energy supply in past years (by energy type)

Unit: One million KLOE

Year	Total supply	Coal and coal product	Crude oil and petroleum products	Natural gas	Biomass energy and waste	Nuclear energy	Hydropower	Geothermal power	Solar photovoltaic	Wind power	Solar thermal energy
2005	13,408.05	3,975.02	7,080.62	985.96	159.50	1,157.41	38.90	-	0.01	0.87	9.75
2006	13,677.08	4121.70	7,128.54	1,057.59	162.81	1,154.47	39.07	-	0.01	2.64	10.24
2007	14,399.60	4,331.15	7,546.65	1,122.09	168.90	1,173.83	42.21	-	0.02	4.20	10.55
2008	13,921.96	4,218.83	7,070.59	1,219.64	172.98	1,182.16	41.14	-	0.04	5.62	10.95
2009	13,641.31	3,853.92	7,174.08	1,191.06	163.80	1,203.72	35.82	-	0.09	7.52	11.32
2010	14,300.78	4,223.62	7,160.65	1,478.91	170.69	1,205.38	40.08	-	0.21	9.81	11.43
2011	13,883.79	4,400.14	6,400.69	1,625.81	173.24	1,219.51	38.22	-	0.59	14.26	11.32
2012	14,161.10	4,253.54	6,771.89	1,708.73	175.90	1,170.43	54.18	-	1.53	13.51	11.40
2013	14,406.96	4,404.39	6,833.37	1,705.26	176.41	1,205.69	51.82	-	3.07	15.67	11.28
2014	14,853.20	4,394.08	7,184.21	1,802.63	173.01	1,227.40	41.26	-	5.05	14.34	11.22
2015	14,613.16	4,337.86	7,040.16	1,928.00	174.34	1,056.04	42.17	-	8.12	14.57	11.35
2016	14,662.84	4,303.72	7,172.31	2,003.00	168.60	916.77	62.70	-	10.60	13.92	11.21
2017	14,657.24	4,424.69	7,103.90	2,220.80	162.19	649.92	52.05	-	15.93	16.46	11.31
2018	14,862.69	4,375.52	7160.50	2,260.64	168.94	801.56	42.82	0.00	25.92	16.31	10.47
2019	14,840.04	4,430.38	6962.26	2,222.21	169.65	935.94	52.98	0.07	38.36	18.08	10.11
2020	13,848.06	4,154.45	6,117.21	2,377.42	167.64	910.37	28.85	0.18	58.24	23.25	10.44

Source: Bureau of Energy, Ministry of Economic Affairs, "Energy Statistical Monthly Report", September 2021

II. Energy consumption

In terms of Taiwan's overall energy consumption structure, petroleum products are the majority. In 2020, petroleum products accounted for 51.86%, electricity accounted for 30.35%, coal and coal products accounted for 8.22%, natural gas accounted for 6.01%, thermal energy accounted for 2.93%, and biomass energy and waste accounted for 0.50%, and solar thermal energy accounted for 0.12% of the total energy consumption.

In terms of total energy consumption, Taiwan's energy consumption has continued to grow from 2005 to 2020, from 76.85 million kiloliters of oil equivalent (KLOE) to 85.4 million kiloliters of oil equivalent (KLOE), a growth rate of 11.13%. In 2020, under the influence of the COVID-19 pandemic, Taiwan's energy consumption increased, with a growth rate of 0.46% compared to 2019.

As to the growth of energy consumption for various types of energy, due to changes in the lifestyle of the general public under the influence of the COVID-19 pandemic, home activities are the major contributors, leading to the largest growth rate of energy consumption in the residential sector in 2020, with an annual growth rate of 5.40%. The annual growth rate of the industrial sector was 0.22%, which is attributed to the energy consumption increase in the electronics industry due to the booming of the long-distance related business opportunities, while the energy consumption increase was partially offset by the energy consumption decreases of other industries according to the impact of the pandemic. For the transportation sector, since that the spread of the COVID-19 pandemic is properly controlled in Taiwan, and with the implementation of border control, most of the trips were domestic, which increased the demand for road-use petroleum, leading to an increase in energy consumption by 0.79%, as shown in Figure 1.6-2.

Table 1.6-2: Energy consumption in past years (by energy type)

Unit: One million KLOE

Year	Total consumption	Coal and coal product	Petroleum products	Natural gas	Biomass energy and waste	Electricity	Solar thermal energy	Thermal energy
2005	7,684.51	722.51	4,444.64	248.04	47.49	2,087.48	9.75	124.59
2006	7,787.32	761.10	4,414.93	246.91	49.15	2,159.24	10.24	145.74
2007	8,257.35	771.64	4,738.64	256.91	49.51	2,231.06	10.55	199.04
2008	7,928.35	717.48	4,515.76	261.20	50.92	2,194.78	10.95	177.24
2009	7,889.43	665.99	4,603.84	264.41	46.45	2,109.05	11.32	188.35
2010	8,399.91	795.68	4,762.20	302.57	51.31	2,268.56	11.43	208.16
2011	8,163.48	855.14	4,401.64	338.50	48.85	2,313.27	11.32	194.75
2012	8,187.67	835.71	4,419.03	370.61	46.61	2,303.96	11.40	200.34
2013	8,457.60	910.95	4,586.73	368.36	46.78	2,342.29	11.28	191.20
2014	8,575.11	863.58	4,695.20	367.01	49.03	2,399.40	11.22	189.67
2015	8,601.33	863.58	4,719.08	385.14	49.51	2,389.07	11.35	183.60
2016	8,658.94	880.92	4,707.85	395.30	45.70	2,440.68	11.21	177.28
2017	8,603.84	830.54	4,617.54	433.25	43.24	2,497.77	11.31	170.19
2018	8,766.50	724.06	4,703.65	470.51	43.71	2,547.21	10.47	266.89
2019	8,500.92	722.93	4,456.97	482.60	42.92	2,539.10	10.11	246.29
2020	8,540.01	702.16	4,429.08	513.50	42.91	2,591.92	10.44	250.00

Source: Bureau of Energy, Ministry of Economic Affairs, "Energy Statistical Monthly Report", September 2021

III. Energy efficiency indicator

Taiwan's energy consumption per capita is growing. From 2005 to 2020, the energy consumption has increased from 3,380.81 liters of oil equivalent (LOE) to 3,621.38 liters of oil equivalent (LOE), with a growth rate of 7.12%. In 2019, the energy consumption per capita showed a downward trend compared with the previous year, with a growth rate of -3.10%. Although energy consumption in 2020 has increased compared with that during the last year, it is still lower than that in 2018.

During the same period (from 2005 to 2020), Taiwan's energy productivity increased from NT$ 156.8/LOE to NT$ 231.78/LOE. The growth rate in 2020 increased by 2.65% compared with the previous year, suggesting that the economic output value created by per unit energy use has increased. The overall energy efficiency has improved, as shown in Table 1.6-3.

1.7 Transportation

The transportation industry includes land, sea, and air transportation. The Ministry of Transportation and Communications is in charge of national transportation administration and transportation, covering the four major fields of transportation, tourism, meteorology, and communications. Land transportation includes railway (including general railway, mass rapid transit, high-speed railway) and road transportation. Sea transportation includes shipping and commercial port businesses. Air transportation includes airlines and air terminals. The following is a brief introduction of Taiwan's land, sea and air transportation:

Table 1.6-3: Energy efficiency indicators of Taiwan

Item/Year	Mid-year population	Average energy consumption per capita	Elasticity of Domestic Energy Consumption	Energy productivity (Real GDP/ Domestic energy consumption)	Energy intensity (Domestic energy consumption/real GDP)	Electricity consumption per capita
Unit	Thousand people	LOE/person		NTD/LOE	LOE/NT$ thousand	kWh/person
2005	22,729.8	3,380.81	0.31	156.81	6.38	9,611.08
2006	22,823.5	3,411.98	0.23	163.67	6.11	9,900.64
2007	22,917.4	3,603.08	0.88	164.93	6.06	10,187.99
2008	22,997.7	3,447.45	-4.99	173.15	5.78	9,987.35
2009	23,078.4	3,418.53	0.30	171.19	5.84	9,563.70
2010	23,140.9	3,629.89	0.63	177.26	5.64	10,259.19
2011	23,193.5	3,519.72	-0.77	189.10	5.29	10,437.67
2012	23,270.4	3,518.50	0.13	192.73	5.19	10,361.32
2013	23,344.7	3,622.92	1.33	191.21	5.23	10,500.19
2014	23,403.6	3,664.01	0.29	197.49	5.06	10,729.12
2015	23,462.9	3,665.92	0.21	199.77	5.01	10,655.94
2016	23,515.9	3,682.16	0.31	202.74	4.93	10,861.57
2017	23,555.5	3,652.58	-0.19	210.80	4.74	11,096.96
2018	23,580.1	3,717.76	0.68	212.65	4.70	11,304.80
2019	23,596.0	3,602.69	-1.02	225.79	4.43	11,261.22
2020	23,582.2	3,621.38	0.15	231.78	4.31	11,502.21

Source: Bureau of Energy, Ministry of Economic Affairs, "Energy Statistical Monthly Report", September 2021

Table 1.7-1: Taiwan transportation statistics

Year	Road length (km)	Road surface area (Hectare)	Motor vehicle	Passengers traffic by motor carriers		Civil aviation transportation volume		
			Number of registrations (Thousand vehicles)	Passenger-KMS (Million Passenger-kms)	Ton-KMS (Million Ton-kms)	Aircraft movement (Thousand movements)	Number of passengers (Thousand passengers)	Freight tonnage (Thousand tons)
2010	40,353	478,911	21,650	16,307	29,632	360	41,091	2,336
2011	40,995	483,006	22,226	17,040	29,551	385	42,856	2,179
2012	41,924	490,797	22,346	17,586	29,851	405	46,860	2,091
2013	42,520	501,392	21,562	17,928	38,474	427	50,336	2,085
2014	41,916	489,678	21,290	18,384	37,852	455	55,357	2,222
2015	41,950	490,042	21,400	17,565	37,805	481	58,156	2,151
2016	43,365	526,241	21,511	17,379	38,533	527	63,253	2,233
2017	43,206	532,555	21,704	17,053	40,351	509	65,979	2,416
2018	43,133	533,968	21,871	17,136	44,169	547	68,904	2,463
2019	43,120	534,698	22,112	17,064	44,370	581	72,157	2,315
2020	42,138	532,827	22,297	14,209	44,550	343	18,998	2,435

Source: Ministry of Transportation and Communications, "Transportation Statistics Summary", 2020

I. Land transportation

Land transportation mainly includes road transportation and rail transportation. The total distance of roads in Taiwan (including national highways, provincial highways, city roads, county roads, district roads, township roads, and accommodation highways) is 21,752.0 km by the end of 2020, and the road density is 0.6 km/km^2. Taiwan has nine national highways, 48 main-line and 49 branch-line provincial highways (97 in total), 156 city and county roads, 2,267 district and township roads, and 35 accommodation highways. Statistics of land transportation volume in 2020 are shown in Table 1.7-2.

As of the end of 2020, there are 241 stations on all the lines of Taiwan Railway, with a total operating distance of 1,065.0 km, including 742.1 km for dual lines and 322.9 km for single lines. Among them, 997.7 km is for electrified section, and 67.3 km is for non-electrified sections. There are 4,128 railway vehicles, including 252 traction locomotives, 2,305 passenger cars, and 1,571 freight cars.

Table 1.7-2: Statistics of land transportation volume in 2020

Item				Unit	2020	2019	Percent change (%)
Railways	Taiwan Railway passengers			Million passengers	204	236	-13.8
	Taiwan Railway passenger-kms			Million passenger-kms	9,314	11,046	-15.7
	Percentage of seat utilization of passenger	Tze-Chiang Limited Express		%	58.0	70.1	-12.1
		Chu-Kuang Limited Express		%	32.7	40.7	-8.0
		Local Train		%	56.7	66.1	-9.4
		Express		%	31.2	27.5	3.7
	Taiwan Railway freight tonnage			10,000 tons	726	731	-0.8
	Taiwan Railway freight ton-kms			Million ton-kms	495	517	-4.2
	MRT passengers			10,000 passengers	76,854	88,943	-13.6
	MRT passenger-kms			Million passenger-kms	6,330	7,404	-14.5
Railways	HSR passengers			10,000 passengers	5,724	6,741	-15.1
	HSR passenger-kms			Million passenger-kms	9,912	11,994	-17.4
Highways	Length of road			km	42,138	43,120	-2.3
	Passenger traffic	Number of passengers		Million passengers	1,079	1,247	-13.5
		Passenger-kms		Million passenger-kms	14,209	17,064	-16.7
	City bus	Number of passengers		Million passengers	977	1,118	-12.6
		Passenger-kms		Million passenger-kms	8,779	9,975	-12.0
	Highway bus	Number of passengers		Million passengers	102	129	-21.4
		Passenger-kms		Million passenger-kms	5,430	7,090	-23.4
	Highway trucking	Freight tonnage		Million tons	556	560	-0.6
		Ton-kms		Million ton-kms	44,550	44,370	0.4
	Express-way	Traffic of toll stations	Total	10,000 cars	607,532	597,497	1.7
			Small vehicle	10,000 cars	537,798	524,936	2.5
			Bus and truck	10,000 cars	39,071	41,952	-6.9
			Tractor	10,000 cars	30,663	30,608	0.2

Table 1.7-2: Statistics of land transportation volume in 2020

Item			Unit	2020	2019	Percent change (%)
Highways	Registered motor vehicles (by vehicle type)	Total	1,000 vehicles	22,297	22,112	0.8
		Bus	1,000 vehicles	33	33	-2.3
		Heavy truck	1,000 vehicles	167	166	1.0
		Passenger car	1,000 vehicles	6,985	6,919	0.9
		Light truck	1,000 vehicles	941	934	0.7
		Specially constructed vehicle	1,000 vehicles	68	66	2.2
		Motorcycle	1,000 vehicles	14,104	13,993	0.8
	Registered motor vehicles	Car	1,000 vehicles	8,193	8,119	0.9
		Motorcycle	1,000 vehicles	14,104	13,993	0.8
	Motor vehicles per 100 population		Vehicle/100 population	94.6	93.7	1.0

Source: Ministry of Transportation and Communications, "Transportation Statistics Summary", 2020

In addition, the north-south high-speed railway runs 350 kilometers from Taipei Nangang Station in the north to Zuoying Station in Kaohsiung in the south. The high-speed railway significantly shortens the travel time of land transportation between the north and the south. In conjunction with the convenient shuttle system of the high-speed railway station, a one-day living circle in the Western Corridor is gradually formed. The Ministry of Transport has proposed the "National High-speed Rail Network Overall Plan" on January 3, 2020. It is actively conducting the feasibility study on extending the high-speed rail to Pingtung, the comprehensive plan of extending the high-speed rail to Yilan, the feasibility study of the Yilan-Hualien-Taitung express railway, the feasibility study of the South-Link express railway, the comprehensive plan of Keelung MRT, and the feasibility study on the dual-track of the Taiwan Railway Sea Line. After the completion of the national high-speed railway network, the time for intercity travel will be greatly shortened, allowing one to finish an around-the-island trip in just 6 hours and achieving the overall goal of the national spatial plan for improving the connectivity of national land.

Mass rapid transit (MRT) system is also an essential type of transportation for Taiwan's metropolitan areas. Currently, the rapid transit systems in the metropolitan areas of Taipei, Kaohsiung, and Taichung, as well as the rapid transit system of the Taiwan Taoyuan International Airport are under operation. They will gradually expand the scope of their services in the future.

II. Sea transportation

Taiwan is surrounded by the sea; therefore, international trade and maritime transportation play an important role in Taiwan's economic and trade development. Currently, Taiwan has seven international commercial ports and four domestic, commercial ports. International route business includes shipping and international cruise tour. The around-the-island transport route serves as the third transportation corridor. The ocean carrier handles its own around-the-island cargo transport business with its own or operated vessels. Container transportation is changed from land to sea, which can effectively reduce the inland traffic congestion due to transporting containers from north to south or the other way around.

There are currently six seaport free trade zones in Taiwan, including Keelung, Taipei, Taichung, Anping, Kaohsiung, and Suao. As of the end of 2020, there are 87 port businesses in operation. According to statistics from the Customs Administration, Ministry of Finance, the annual trade volume was 6.6 million tons, and the trade value was NT$ 280.8 billion.

To effectively utilize Taiwan's port resources, reduce industrial transportation costs, and improve port service quality as well as the international competitiveness of Taiwan's ports, the Executive Yuan approved the "Plan for the Future Development and Construction of International Commercial Ports" (2017-2021) in 2016 and continued to promote the Kaohsiung Intercontinental Container Terminal (ICT) Phase II Project. In terms of freight transportation, Taiwan's port clusters will be integrated ,and a global shipping network will be built. As to passenger transportation, local tourism resources will be combined to strengthen cruise transportation facilities actively, and the promotion of green ports will be listed as an essential policy for the sustainable development of future ports.

III. Air transportation

The civil aviation industry is closely related to the overall economic development. In response to the needs of the development of the air transportation industry, the government has actively reduced the operating restrictions of the operators through freedoms-of-the-air negotiations and consultations, significantly activating Taiwan's air transportation. By the end of 2020, there are eight civil air transport companies operating domestic and international scheduled routes. Presently, Taiwan has signed air agreements with 57 countries or regions, running 210 international scheduled passenger routes and 114 cargo routes, totaling 324 routes to connect 148 cities worldwide. However, due to the impact of the pandemic and strict border controls in various countries, Taiwan's airports totaled 19 million passengers in 2020, a decrease of 73.7% from 2019. Among them, international routes (including Hong Kong and Macau) decreased by 85.2% ,and domestic routes decreased by 17.4%.

1.8 Buildings and urban structures

In the presence of global climate change and scarcity of resources, to allow people to have a healthy and comfortable living environment that is sustainable and energy-saving, the Ministry of the Interior formulated the energy-saving regulations for buildings in 1995. It established the "Green Building Labeling System" based on Taiwan's subtropical high temperature and high humidity climate characteristics. The Green Building Label (EEWH) combines the four major areas of Ecology (E), Energy Saving (E), Waste Reduction (W), and Health (H) to form a building evaluation system that takes energy saving, environmental protection, and ecological sustainability into consideration. Not only is Taiwan the fourth in the world to implement a scientifically quantified green building assessment system, but it is also the first to independently develop a green building assessment system for tropical and subtropical high temperature and high humidity climates. Since 2017, it has accepted applications for the certification of overseas green building labels to expand the scope of Taiwan's green building certification.

According to statistics from the Ministry of the Interior, the number of green building labels granted in 2020 reached 848. As of 2020, the total number of green buildings nationwide has reached 9,255. There are cases in which green building labels have been granted in all counties and cities, and the percentage of private construction projects with green building labels has also increased year by year, from 7 projects in 2002 to 358 projects in 2020.

To accelerate the promotion of green buildings, the Executive Yuan has been implemented a series of green building promotion plans since 2001, requiring publicly-owned new buildings with a total construction cost of more than NT$ 50 million to obtain a green building label. Since 2014, it has further requested that the total construction cost of publicly-owned new buildings not exceeding NT$ 50 million must meet the requirements of the two indicators of "daily energy saving" and "water resources" to achieve complete green building design control for publicly-owned new buildings and lead private constructions to follow the trend.

1.9 Waste

In the early days, waste disposal was mainly carried out through landfills. With the rise of awareness of land use, environmental protection, and resource recycling, the waste disposal policy has changed significantly. The promotion of policies such as the “Installation of large-scale incinerators” in 1990, the “Four-in-one recycling of resources” in 1997, the “Zero waste” in 2004, the “Mandatory waste sorting and recycling” in 2005, and the “Sustainable material management” in 2011, the approach in handling waste disposal in Taiwan has gradually shifted from landfill in the past to resource recycling

and reuse, continuing to decrease the volume of waste for final disposal.

According to the 2020 Yearbook of Environmental Protection Statistics, general waste disposal is divided into incineration, sanitary landfill, resource recycling, large waste recycling and reuse, and food waste recycling. The waste production in 2019 was 9,812,418 tons, most of which was treated by resource recycling, accounting for 50.6%, followed by incineration and sanitary landfill, accounting for 41.2% and 0.9%, respectively. Regarding the declaration of industrial waste, the total amount of industrial waste declared for disposal in 2019 was 19,845,377 tons, handled by contracted or joint-processing, self-processing, reuse, and overseas processing. Among them, reuse was the majority, accounting for 84.0%, followed by contracted or joint-processing, accounting for 12.4%. These statistics suggest that Taiwan's waste disposal is mainly based on the approach of recycling.

As for the domestic sewage treatment, through the sewer construction plan, priority is given to promoting the recycling and reuse of waste sludge and discharged water from sewage treatment plants, increasing the connection rate for sewage treatment year by year, and properly carrying out centralized treatment to ensure the public health and reduce water pollution. As of July 2021, the national sewage treatment rate reached 66.11%. Regarding industrial wastewater, in response to the needs of domestic and foreign production, the types of wastewater generated by businesses are becoming more and more diverse. To effectively manage the wastewater (sewage) discharged from businesses or sewer systems and reinforce the maintenance of the environmental ecosystem, the Environmental Protection Administration cooperates with the promotion of the resource recycling policy and the amendment of the "Water Pollution Control Act" and its related sub-laws, to actively strengthen the management of water measures and tightens the wastewater discharge standards of specific industries, to improve the maintenance and management of water resources and create a livable living environment. In 2019, a total of 16,535 businesses nationwide were inspected (34,042 inspections), 4,382 businesses were sampled (8,120 samples), and 1,726 businesses (2,078 penalties) were penalized.

1.10 Agriculture, forestry, fishery, and animal husbandry

I. Production overview

Taiwan is located in the tropical and subtropical zone, with a warm climate suitable for crop growth; however, it is also prone to pests and diseases. In addition, frequent typhoons, heavy rains, and earthquakes restrict agricultural development. Due to the constraints of the natural environment, most of the farms are managed by small-scale farmers, and the production costs are relatively high. Both agricultural productivity and product quality have continued to improve in recent years. In 2020, the total agricultural production value reached NT$ 503.9 billion. Agriculture accounts for 1.65% of gross domestic product, which is significantly lower than the rapid-developing non-agricultural sectors.

In terms of agricultural land use, in 2020, Taiwan's arable land area reached 790,000 hectares, of which rice is the largest cultivated crop, with a harvested area of 262,000 hectares. The cultivated area for fruits was about 183,000 hectares, while the cultivated area for vegetables and grain products was about 143,000 and 76,000 hectares, respectively.

As to animal husbandry, pigs (42.77%), chickens (27.91%), and eggs (12.81%) were the top three in terms of production output value in 2020. As for the production of livestock and poultry and by-products, 8.184 million pigs were slaughtered, 380 million chickens were slaughtered, and 8.2 billion eggs were produced.

In terms of fisheries, the total output in 2020 was about 885,000 tons, with a total output value of about NT$ 71.32 billion. Among them, offshore fisheries accounted for the largest proportion, accounting for 48.8% of the total output, followed by inland aquaculture, accounting for 28.9% of the total production. Affected by climate change, the distribution of offshore fishing grounds and fishery resources have changed significantly. The output of offshore fisheries decreased by 23.0% compared with 2019. The production of coastal fisheries, inland aquaculture, and offshore fisheries also showed a decreasing trend, with a decrease of 20.8%, 5.1%, and 2.0%, respectively, compared with 2019.

II. Forestry and nature conservation

According to the results of the fourth forest resource survey conducted by the Forestry Bureau of

the Council of Agriculture, Executive Yuan, the total forest area of the country (including Jinmen and Lianjiang counties) is 2,197,090 hectares, and the forest coverage is 60.71%, which is about twice the global average. Among them, the forest land defined by the "Forestry Act" has a forest coverage area of 1,781,660 hectares; the land other than forest land has a forest coverage area of 415,430 hectares, and the national forest area per capita is 0.092 hectares/person. The broad-leaved forest is the majority in Taiwan, with an area of 1,469,898 hectares (accounting for 67%) followed by coniferous forest with an area of 299,216 hectares (accounting for 14%), coniferous broad-leaved mixed forest with an area of 171,346 hectares (accounting for 8%), and bamboo forest with an area of 112,548 hectares (accounting for 5%) as shown in Figure 1.10-1. The total volume is about 502 million cubic meters, and the average volume per hectare is 228 cubic meters.

By the end of 2020, the forest area of the state-owned forestry business zone was 1,533,957 hectares, with forested land accounting for 90.89% and non-forested land accounting for 9.11%; among the forested land, natural forests accounted for 80.76% and planted forests accounted for 19.24%. Currently, the domestic use of wood is highly dependent on imports, and the development of the forest plantation industry is mainly based on private forests, supplemented by state-owned forests. The current goal is to promote the sustainable management and utilization of domestic timber, gradually provide domestic timber with stable sources and quantities, and expand the market demand for domestic wood and bamboo material, promoting the development of the forest industry.

The Forestry Bureau has promoted the policy for revitalizing the forestry industry since 2017. It not only pays attention to the development of forest products by businesses in the forestry industry but also focuses on the diversified use of non-timber resources, including the promotion of the "Forestry Sustainability Diversified Guidance Plan" and the release of the "Under-forest Economy Management and Utilization Review Guideline". In addition, to implement sustainable forest management, the forest verification system of the Forest Stewardship Council (FSC) is adopted as a benchmark to introduce a state-owned forest management system. Since 2016, the demonstration forest area has been used to conduct practices for FSC management, hoping that the management of state-owned forests can meet the most stringent international standards. In this way, the concept of sustainable forest management can be truly internalized and implemented in the thinking and work of forest staff.

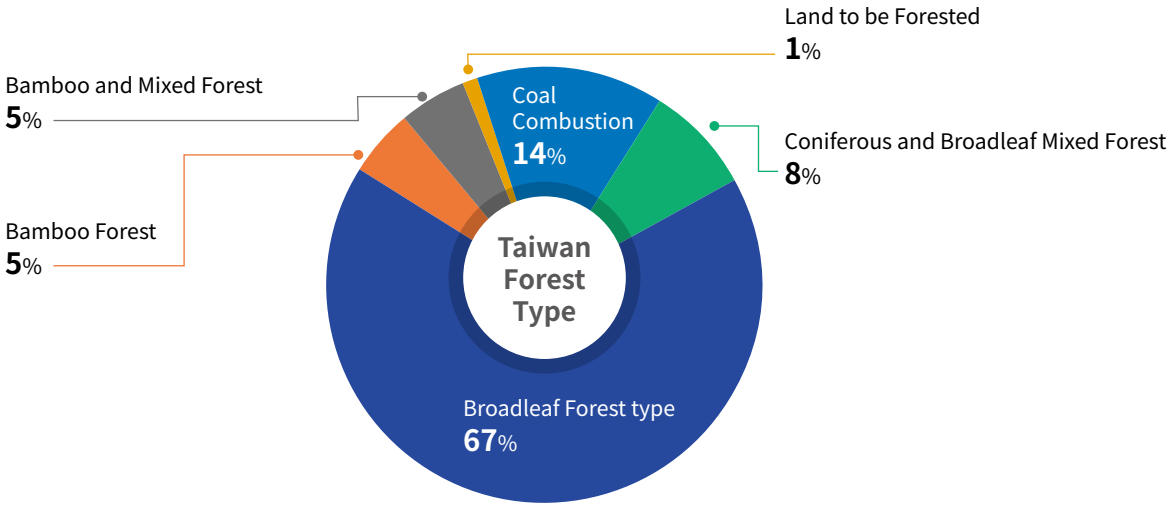

Figure 1.10-1: Types of forest in Taiwan

Source: Council of Agriculture, Executive Yuan, "Fourth Forest Resources Survey Report", 2015.

References

1. Website of National Statistics, R.O.C.(Taiwan) : https://www.stat.gov.tw/lp.asp?ctNode=497&CtUnit=1818&BaseDSD=29
2. Official website of the Ministry of the Interior, Land Administration Section : https://www.land.moi.gov.tw/chhtml/content/68?mcid=3224
3. Website of the Construction and Planning Agency, Ministry of the Interior, Business News Section - Statistics of national connection rate for sewage treatment and overall sewage treatment rate : https://www.cpami.gov.tw/
4. Website of Taiwan Power Company : https://www.taipower.com.tw/tc/page.aspx?mid=212&cid=120&cchk=f3a1b1e0-03e5-45fa-b72e-b28c5cb94f37
5. Ministry of Transportation and Communications, “2020 Transportation Yearbook”, 2021 : https://www.motc.gov.tw/ch/home.jsp?id=21&parentpath=0%2C7&mcustomize=yearbook_zip_list.jsp&yearid=8270&dataserno=109&aplistdn=ou=data,ou=motcyear,ou=ap_root,o=motc,c=tw&toolsflag=Y&imgfolder=img%2Fstandard
6. Ministry of Transportation and Communications, “2020 Transportation Statistics Summary”, 2020 : https://www.motc.gov.tw/ch/home.jsp?id=59&parentpath=0,6
7. Central Weather Bureau, Ministry of Transportation and Communications, "Global and Taiwan Temperature Trend Analysis Report", 2020 : https://www.cwb.gov.tw/Data/climate/Watch/trend/trend-monitor_2019.pdf
8. Central Weather Bureau, Ministry of Transportation and Communications, "Climate Monitoring Report", December 2020 : https://www.cwb.gov.tw/V8/C/C/Watch/watch_1.html#
9. Official website of the Executive Yuan, National Conditions of R.O.C. (Taiwan) : https://www.ey.gov.tw/state/
10. Official website of the Executive Yuan, Policies and Plans : https://www.ey.gov.tw/Page/448DE008087A1971/1236c5fe-c03e-46b0-b2bb-904660cd0f2b
11. Official website of the Executive Yuan, Organization and Responsibilities : https://www.ey.gov.tw/Page/62FF949B3DBDD531
12. Council of Agriculture, Executive Yuan, "2019 Forestry Bureau Annual Report", December 2020 : https://www.forest.gov.tw/0003806
13. Council of Agriculture, Executive Yuan, "2019 Fishery Statistics Annual Report", December 2020 : https://www.fa.gov.tw/cht/PublicationsFishYear/content.aspx?id=34&chk=45c1a506-e4ff-4f0f-9fad-c898cc1eae42
14. Council of Agriculture, Executive Yuan, "Forestry Statistics (2019)", July 2020 : https://www.forest.gov.tw/0003067
15. Council of Agriculture, Executive Yuan, "Fourth Forest Resources Survey Report", 2015 : https://www.forest.gov.tw/0002393
16. Council of Agriculture, Executive Yuan, "Annual Report on Agricultural Statistics (2019)", July 2020 : https://www.coa.gov.tw/ws.php?id=209
17. Environmental Protection Administration, Executive Yuan, "Annual Report on Environmental Protection Statistics of the Republic of China", 2020 : https://www.epa.gov.tw/Page/B84B65A4FDDF5864
18. Environmental Protection Administration, Executive Yuan, Water Quality Protection website : https://ts03.gi-tech.com.tw/Water/index.aspx
19. National Development Council, "Population Projections for the R.O.C. (Taiwan): 2020~2070", August 2020 : https://pop-proj.ndc.gov.tw/download.aspx?uid=70&pid=70
20. National Development Council, "Urban and Regional Development Statistics", 2020 : https://www.ndc.gov.tw/Content_List.aspx?n=3767B021A1D7691F
21. Official website of the Ministry of Economic Affairs : https://www.moea.gov.tw/Mns/populace/home/Home.aspx
22. Bureau of Energy, Ministry of Economic Affairs, "Energy Statistics Handbook 2019", 2019 : https://www.moeaboe.gov.tw/ECW_WEBPAGE/FlipBook/2019EnergyStaHandBook/index.html

Chapter 2

Statistics and Trend Analysis of Greenhouse Gas Emissions and Absorption

2.1 Greenhouse Gas Inventory Compilation Process and Statistical Method

2.2 Statistics on Greenhouse Gas Emissions and Removals

2.3 Statistics on Greenhouse Gas Emissions and Removals by Gas

2.4 Inventory of Greenhouse Gas Emissions and Absorption Statistics by Sector

2.5 Greenhouse Gas Key Sources and Trend Analysis

Chapter 2 Statistics and Trend Analysis of Greenhouse Gas Emissions and Absorption

Following international standards, the government of Taiwan regularly compiles the statistics on greenhouse gas emissions from various government agencies, including the Bureau of Energy (Ministry of Economic Affairs, MOEA), Industrial Development Bureau (MOEA), Council of Agriculture (Executive Yuan), and Environmental Protection Administration (Executive Yuan), and publish the "National Greenhouse Gas Inventory Report" (hereinafter referred to as the National Inventory Report) every year to illustrate the status and trend of greenhouse gas emissions in Taiwan.

2.1 Greenhouse Gas Inventory Compilation Process and Statistical Method

The statistics on national greenhouse gas emission data are carried out based on the "2006 IPCC Guidelines for National Greenhouse Gas Inventories" published by the United Nations Intergovernmental Panel on Climate Change (IPCC) in 2006, the "Good Practice Guidance" as well as the "Uncertainty Management" updated by the IPCC in 2000, and the "2003 LULUCF (Land Use, Land Use Change, and Forestry) Good Practice Guidance."

For the compilation process, the statistics on greenhouse gas resources and sinks of the responsible units are conducted by related governmental departments in accordance with Article 13 of the Greenhouse Gas Reduction and Management Act. After the statistics are reviewed by the Greenhouse Gas Inventory Review Committee of various sectors, they will be submitted to the National Greenhouse Gas Inventory Review Committee for review as shown in Figure 2.1-1. Finally, a National Inventory Report will be coordinated and released by the Environmental Protection Administration, Executive Yuan.

According to the above-mentioned international

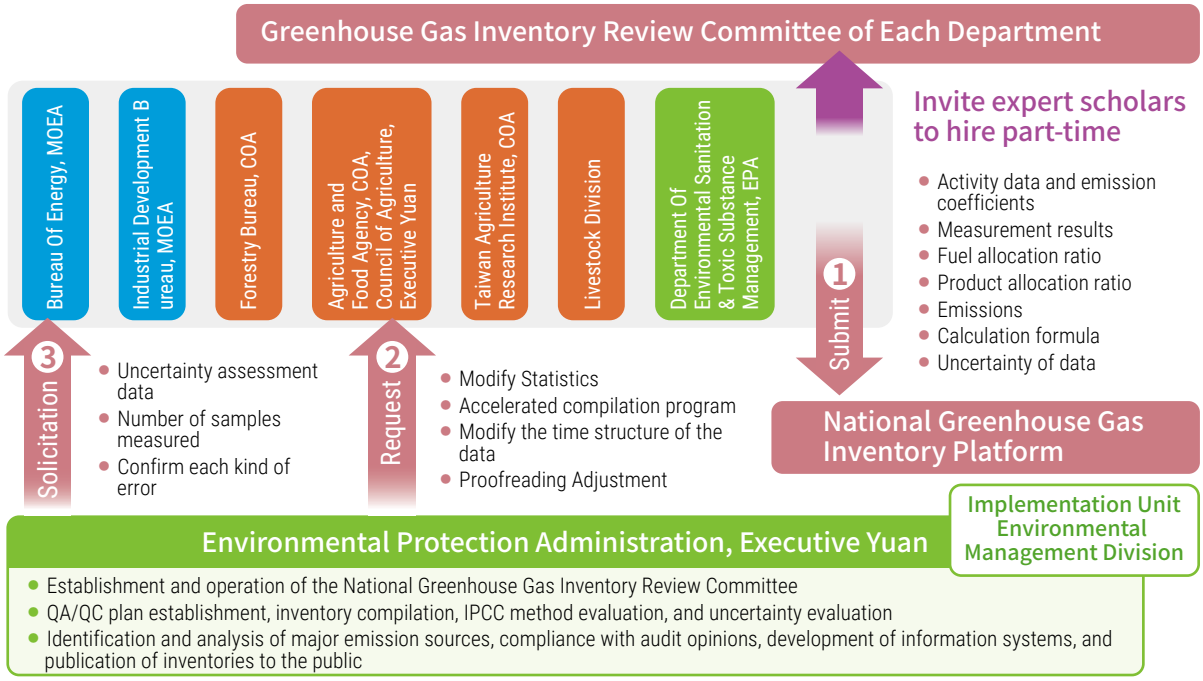

Figure 2.1-1 National Greenhouse Gas Inventory Preparation Procedure

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

guidelines, the National Inventory takes 1990 as the base year and performs statistics on the data of resources and sinks for the seven greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3), that are defined by Article 3 of the Greenhouse Gas Reduction and Management Act. The statistics are divided into five sectors, namely "Energy," "Industrial processes and product use," "Agricultural," "Land use, land use change and forestry," and "Waste." The responsible unit of each sector is shown in Table 2.1-1:

Table 2.1-1 Responsible units of the National Greenhouse Gas Inventory

Sector	Responsible unit
Energy sector	Bureau of Energy, MOEA
Industrial processes and product use sector	Industrial Development Bureau, MOEA
Agricultural sector	Council of Agriculture, Executive Yuan
Land use, land use change and forestry sector	Council of Agriculture, Executive Yuan
Waste sector	Environmental Protection Administration, Executive Yuan

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

The sources of data and coefficients of various sectors in the National Greenhouse Gas Inventory of Taiwan are described as follows:

I. Energy Sector

The types of greenhouse gases emitted by the energy sector include carbon dioxide, methane, and nitrous oxide. The calculation method for the greenhouse gas emissions depends on the data classification method. The calculation method for carbon dioxide emission is based on the reference method and sector method of the 2006 IPCC Guidelines, while the emissions of other non-carbon dioxide greenhouse gases are estimated based on the emission coefficients.

For the activity data, since the classification principles of the energy sector and fuel are the same as those of the 2006 IPCC Guidelines, the activity data source of the statistics of the greenhouse gas inventory of the energy sector is based on the energy balance sheet announced by the Bureau of Energy, Ministry of Economic Affairs.

Regarding the selection of coefficients, the emission coefficients used to calculate greenhouse gas emissions are mainly based on those announced by the 2006 IPCC Guidelines, including Carbon Emission Factors (CEF), Fraction of Carbon Oxidized, and Fraction of Carbon Stored. As for the energy emission coefficients that are not listed in the 2006 IPCC Guidelines, they are based on the emission coefficients announced by other countries. For example, the emission coefficients of waste tires are based on those published by the U.S. Environmental Protection Agency. The principle is to adopt the gross heating value applicable to the country's cogeneration plant.

II. Industrial Processes and Product Use Sector

The greenhouse gases emitted by the industrial processes and product use sector include carbon dioxide, methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons, sulfur hexafluoride, and nitrogen trifluoride. The source of activity data for each business/production in the industrial processes and product use sector is mainly based on the statistics announced by the government. The activity data is accountable, low in error rate, and continuous. If no government-announced statistics are available, statistics announced by industrial associations or statistics collected from the actual surveys conducted for businesses can be used instead.

Regarding the selection of coefficients, the emission coefficients used to calculate greenhouse gas emissions are based on those announced by the 2006 IPCC Guidelines and adjusted according to the production condition of Taiwan. Among them, some activities have established local emission

coefficients for Taiwan, while some activities have directly measured the actual emissions instead of using the emission coefficients. Activities that have completely measured the actual emissions or established the local emission coefficient for Taiwan include the electronics industry (2.E), the use of substitutes for ozone-depleting substances (2.F), the manufacture and use of other products (2.G), and others (2.H). Some industries that have measured the actual emissions or established local emission coefficients for Taiwan include the mining industry (2.A), the chemical industry (2.B), and the metal manufacturing industry (2.C).

III. Agricultural Sector

The types of greenhouse gases emitted by the agricultural sector include methane, nitrous oxide, and a small amount of carbon dioxide. For the activity data, the statistics of the agricultural sector in Taiwan from 1990 to 1999 were based on the "Taiwan Agriculture Annual Report" issued by the Department of Agriculture and Forestry, Taiwan Provincial Government. Since 2000, the "Agricultural Statistics Annual Report" compiled by the Council of Agriculture (Executive Yuan) has been used for reference.

Regarding the selection of coefficients, the emission coefficients used to calculate greenhouse gas emissions are mainly based on the local values from research reports. If the coefficients are not available, the values recommended by the 2006 IPCC Guidelines will be used instead. The local data that are based on the coefficients announced by the 2006 IPCC Guidelines published include Gastrointestinal fermentation of livestock and poultry (3.A), livestock and poultry manure treatment (3.B), rice planting (3.C); Using the 2006 ICCP Guideline, however includes agricultural soil (3.D), the burning of crop residue (3.F), and urea use. The burning of grassland (3.E), lime treatment (3.G), and organic fertilizers (3.I) are temporarily excluded in the calculations due to few new or relevant operational management practices or their reduced usage.

IV. Land Use, Land Use Change and Forestry Sector

The greenhouse gas removed by the land use and forestry sector is mainly carbon dioxide. At present, only forest lands (4.A) are taken into consideration, including forest-maintained forest land (4.A.1) as well as forest land converted from other lands (4.A.2).

Forestry sector greenhouse gas emissions and sink levels are calculated according to the suggestions in the 2006 IPCC Guidelines, and the estimation methodology is established in accordance with Measurable, Reportable and Verifiable (MRV) principles. When calculating forestry sector greenhouse gasses, the results from the 4th National Forestry Resources database should be used as the basis, and consideration should be taken regarding the annual forestry statistical data taken as activity data; in terms of emissions coefficients, it is otherwise based upon local relevant literature and materials from Taiwan. Discrepancies in values should be adjusted starting with the suggested values from the 2006 IPCC guidelines.

V. Waste Sector

The types of greenhouse gases emitted by the waste sector include carbon dioxide, methane, and nitrous oxide. For the activity data, when the waste sector performs statistics on greenhouse gas emissions, the data on solid waste treatment, wastewater, waste incineration ,and open burning, as well as other waste management activities used by the waste sector, come from the official annual environmental statistic reports of the government, biogas recycling data, incinerator data, water pollution source control data management system, industrial waste control information website, sewer penetration rate and emissions from the food balance sheet.

Regarding the selection of coefficient, the emission coefficient used to calculate greenhouse gas emissions is mainly based on the 2006 IPCC Guidelines and the emission coefficients of other countries (such as Japan), including biological treatment of solid waste (5.B), waste incineration and open burning (5.C), and wastewater treatment and discharge (5.D). Some activities have established the local emission coefficient for Taiwan, mainly solid waste treatment (5.A).

2.2 Statistics on Greenhouse Gas Emissions and Removals

Taiwan's total greenhouse gas emissions in 2019 were 287.060 million tons of carbon dioxide equivalent (CO2e), an increase of 108.35% compared to 1990 (137.776 million tons of CO_2e), and an average annual growth rate of 2.56%. Compared to 2005 (290.552 million tons of CO_2e), the total

greenhouse gas emissions decreased by 1.20%, with an average annual growth rate of -0.09%. Compared to 2018 (297.186 million tons of CO_2e), the total greenhouse gas emissions decreased by 3.41%. The trend and statistical data of greenhouse gas emissions in Taiwan are shown in Figure 2.2-2 and Table 2.2-2.

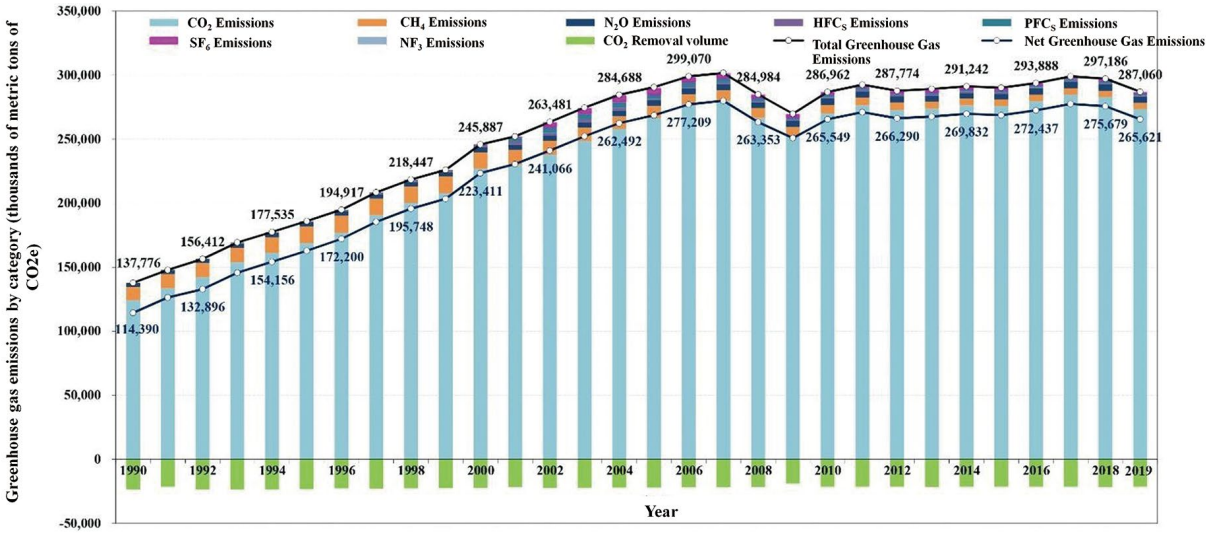

Figure 2.2-1 Trend of total greenhouse gas emissions and removals in Taiwan from 1990 to 2019

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

Table 2.2-1 Emissions and removals of various greenhouse gases in Taiwan from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas	Global warming potential	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Carbon dioxide	1	124,078	133,598	142,182	153,801	161,168	168,887	176,793	190,542	200,162	207,800
Methane	25	10,705	11,030	10,977	11,383	12,141	12,899	13,291	13,001	12,899	13,188
Nitrous oxide	298	2,992	3,262	3,253	3,324	3,371	3,448	3,553	3,377	3,304	3,274
Hydrofluorocarbon	HFC-134a:1,430, etc.	NE	NE	NE	755	855	801	1,305	1,477	2,083	1,609
Perfluorocarbon	PFC-14:7,390, etc.	NE	NE	NE	NE	NE	NE	NE	NE	NE	3
Sulfur hexafluoride	22,800	NE	NE	NE	NE	NE	NE	NE	NE	NE	116
Nitrogen trifluoride	17,200	NE	NE	NE	NE	NE	NE	NE	NE	NE	11
Carbon dioxide removal	1	-23,386	-21,490	-23,516	-23,493	-23,379	-23,233	-22,717	-22,899	-22,699	-22,550
Net greenhouse gas emissions (including LULUCF)		114,390	126,400	132,896	145,770	154,156	162,797	172,200	185,504	195,748	203,450
Total greenhouse gas emissions (excluding LULUCF)		137,776	147,890	156,412	169,263	177,535	186,030	194,917	208,403	218,447	226,000

Greenhouse gas	Global warming potential	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Carbon dioxide	1	226,983	229,927	237,651	248,402	257,883	266,460	276,159	279,800	266,594	252,506
Methane	25	12,556	11,734	11,128	10,607	9,969	9,508	8,886	8,318	7,659	7,044
Nitrous oxide	298	3,887	3,938	4,031	4,048	4,192	4,300	4,800	4,873	4,458	4,622
Hydrofluorocarbon	HFC-134a: 1,430, etc.	2,319	2,619	2,216	2,397	2,451	1,098	1,015	1,122	1,074	1,018
Perfluorocarbon	PFC-14:7,390, etc.	13	2,939	4,143	4,198	4,341	3,470	3,664	3,372	2,082	1,560
Sulfur hexafluoride	22,800	120	746	3,914	4,385	5,193	4,951	3,858	3,381	2,912	2,452
Nitrogen trifluoride	17,200	10	235	398	540	659	765	688	798	204	577
Carbon dioxide removal	1	-22,476	-21,583	-22,415	-22,305	-22,196	-21,918	-21,861	-21,650	-21,631	-18,911
Net greenhouse gas emissions (including LULUCF)		223,411	230,555	241,066	252,271	262,492	268,634	277,209	280,015	263,353	250,868
Total greenhouse gas emissions (excluding LULUCF)		245,887	252,138	263,481	274,576	284,688	290,552	299,070	301,665	284,984	269,779
Greenhouse gas	**Global warming potential**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Carbon dioxide	1	270,148	276,282	272,755	273,797	276,311	275,835	279,705	284,821	282,842	273,515
Methane	25	6,570	6,226	5,890	5,547	5,305	5,093	5,032	4,922	4,891	4,786
Nitrous oxide	298	5,026	4,927	4,841	4,643	4,624	4,593	4,794	5,003	5,092	4,904
Hydrofluorocarbon	HFC-134a: 1,430, etc.	971	1,053	907	1,019	1,048	1,020	1,026	1,023	1,013	1,027
Perfluorocarbon	PFC-14:7,390, etc.	1,770	1,781	1,141	1,345	1,556	1,347	1,441	1,409	1,536	1,420
Sulfur hexafluoride	22,800	2,218	1,918	1,852	1,997	1,730	1,523	1,418	1,416	1,302	935
Nitrogen trifluoride	17,200	258	420	388	773	667	662	472	440	509	473
Carbon dioxide removal	1	-21,413	-21,470	-21,484	-21,499	-21,410	-21,425	-21,451	-21,486	-21,507	-21,440
Net greenhouse gas emissions (including LULUCF)		265,549	271,137	266,290	267,623	269,832	268,648	272,437	277,549	275,679	265,621
Total greenhouse gas emissions (excluding LULUCF)		286,962	292,607	287,774	289,121	291,242	290,073	293,888	299,034	297,186	287,060

Note: NE (not estimated) means that there is no estimate for the emissions and removals.

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

The changes in the emissions and removals of various greenhouse gases from 1990 to 2019 are as follows:

1. Carbon dioxide (CO_2): From 1990 to 2019, the emission increased by 120.44%, with an average annual growth rate of 2.76%. From 1990 to 2019, the removal via sinks decreased by 8.32%, with an average annual growth rate of -0.30%.
2. Methane (CH_4): From 1990 to 2019, the emission decreased by 55.29%, with an average annual growth rate of -2.74%.
3. Nitrous Oxide (N_2O): From 1990 to 2019, the emission increased by 63.91%, with an average annual growth rate of 1.72%.
4. Fluorinated greenhouse gases (SF_6, PFCs, HFCs, NF_3): From 1993 to 2019, the emission decreased by 410.63%, with an average annual growth rate of 5.78%.

2.3 Statistics on Greenhouse Gas Emissions and Removals by Gas

The statistics on Taiwan's greenhouse gas emissions cover carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). Among the seven greenhouse gases, CO_2 is the major greenhouse gas. Its emission is 273.515 million tons of CO_2e (excluding CO_2 removal), accounting for 95.28% of the total greenhouse gases. The CO_2 emissions from fuel combustion in the energy sector accounted for 90.13% of the total CO_2. The percentage of Taiwan's greenhouse gas emissions in 2019 is shown in Figure 2.3-1. The following section explains the statistical results of greenhouse gas emissions and removals for various gases separately.

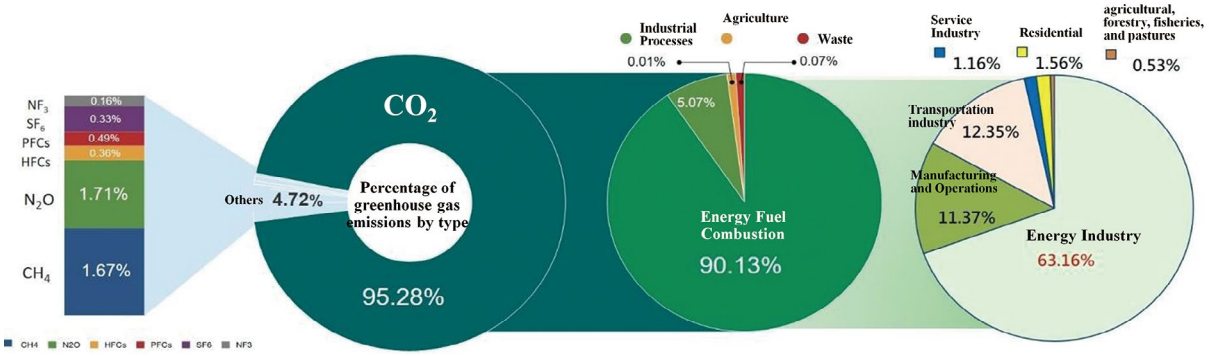

Figure 2.3-1 Percentage of greenhouse gas emissions in 2019 for various gases

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

2.3.1 Carbon dioxide

In terms of the overall emission trend, Taiwan's carbon dioxide emissions in 1990 were 124.078 million tons of CO_2e, and the emissions increased to 273.515 million tons of CO_2e in 2019, resulting in a growth of 120.44% compared with 1990's figures for an average growth rate of 2.76%. The emission trend is shown in Figure 2.3.1-1.

In terms of the structure of resources, the energy sector accounted for the highest percentage in 2019 (94.59%), followed by the industrial processes and product use sector(5.32%). Table 2.3.1-1 shows the emissions and removals of carbon dioxide for various sectors from 1990 to 2019.

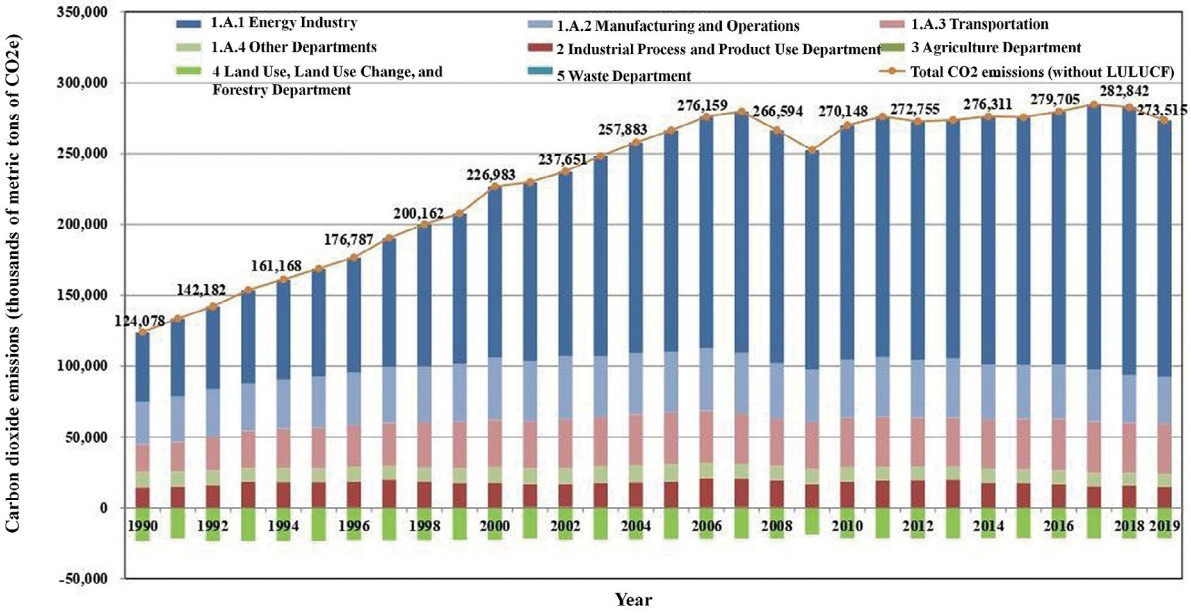

Figure 2.3.1-1 Trend of Taiwan's CO2 emissions from 1990 to 2019

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

Table 2.3.1-1 Taiwan's CO2 emissions from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas resources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
1. Energy sector	109,459	150,803	209,205	247,956	255,331	259,214	247,537	235,868	251,708
1.A.1 Energy industry	49,123	76,400	121,143	156,351	163,615	170,131	164,432	155,166	165,522
1.A.2 Manufacturing industries and construction	30,117	35,763	43,934	42,671	43,994	43,293	39,104	36,698	41,360
1.A.3 Transportation	19,646	28,822	33,207	36,846	36,771	35,419	33,216	33,541	34,652
1.A.4 Other sectors	10,572	9,819	10,922	12,089	10,952	10,370	10,785	10,463	10,174
1.A.4.a Service industry	3,621	2,445	3,205	4,227	4,272	4,232	4,226	4,264	4,204
1.A.4.b Residence	4,005	4,597	5,354	5,235	5,033	5,047	5,017	5,030	4,857
1.A.4.c Agriculture forestry, fishery and husbandry	2,946	2,777	2,362	2,627	1,647	1,091	1,543	1,169	1,113
2. Industrial processes and product use sector	14,458	17,528	17,388	18,094	20,299	19,967	18,558	16,428	18,178
2.A Mining industry (non-metallic products)	10,584	12,766	10,486	11,257	11,014	10,369	9,289	8,467	8,616
2.B Chemical industry	575	858	1,148	1,751	1,721	1,845	1,601	1,623	1,750

Greenhouse gas resources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
2.C Metal industry	3,275	3,884	5,734	5,066	7,544	7,733	7,648	6,317	7,792
2.H Others	23	21	20	20	21	20	20	21	20
3. Agricultural sector	142	151	131	62	59	57	57	55	54
4. Land use and forestry sector	-23,386	-23,233	-22,476	-21,918	-21,861	-21,650	-21,631	-18,911	-21,413
5.Waste sector	20	398	259	348	470	562	443	154	208
Net carbon dioxide emissions (including LULUCF)	100,692	145,648	204,507	244,542	254,298	258,150	244,963	233,595	248,735
Total carbon dioxide emissions (excluding LULUCF)	124,078	168,881	226,983	266,460	276,159	279,800	266,594	252,506	270,148

Greenhouse gas resources and sinks	2011	2012	2013	2014	2015	2016	2017	2018	2019
1. Energy sector	257,096	253,183	254,070	258,481	258,476	262,982	269,462	267,129	258,719
1.A.1 Energy industry	169,884	168,333	168,271	175,180	175,198	178,569	187,135	189,212	181,318
1.A.2 Manufacturing industries and construction	42,298	41,000	42,019	38,953	38,074	38,296	36,741	33,401	32,638
1.A.3 Transportation	35,107	34,284	34,209	34,666	35,506	36,584	36,202	35,207	35,443
1.A.4 Other sectors	9,807	9,566	9,571	9,681	9,698	9,533	9,384	9,310	9,320
1.A.4.a Service industry	3,898	3,635	3,812	3,928	3,941	3,720	3,779	3,317	3,337
1.A.4.b Residence	4,786	4,672	4,484	4,411	4,469	4,537	4,402	4,480	1,469
1.A.4.c Agriculture forestry, fishery and husbandry	1,123	1,259	1,274	1,343	1,287	1,276	1,203	1,512	1,514
2. Industrial processes and product use sector	18,985	19,369	19,529	17,644	17,219	16,557	15,199	15,525	14,553
2.A Mining industry (non-metallic products)	9,577	9,333	9,866	8,728	8,345	7,108	6,262	6,403	6,501
2.B Chemical industry	1,768	1,714	1,749	1,884	1,854	1,760	1,709	1,684	1,666
2.C Metal industry	7,620	8,301	7,894	7,013	7,000	7,670	7,208	7,419	6,368
2.H Others	20	21	19	19	20	19	20	19	17

Greenhouse gas resources and sinks	2011	2012	2013	2014	2015	2016	2017	2018	2019
3. Agricultural sector	53	55	45	40	38	34	31	30	29
4. Land use and forestry sector	-21,470	-21,484	-21,499	-21,410	-21,425	-21,451	-21,486	-21,507	-21,440
5.Waste sector	149	149	153	146	103	132	129	159	214
Net carbon dioxide emissions (including LULUCF)	254,812	251,271	252,298	254,901	254,410	258,254	263,336	261,335	252,075
Total carbon dioxide emissions (excluding LULUCF)	276,282	272,755	273,797	276,311	275,835	279,705	284,821	282,842	273,515

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

2.3.2 Methane

In terms of the overall emission trend, Taiwan's methane emissions in 1990 were 10.705 million tons of CO_2e, and the emissions were reduced to 4.786 million tons of CO_2e in 2019, resulting in a decrease of 55.29% or an average growth rate of -2.74%. The emission trend is shown in Figure 2.3.2-1.

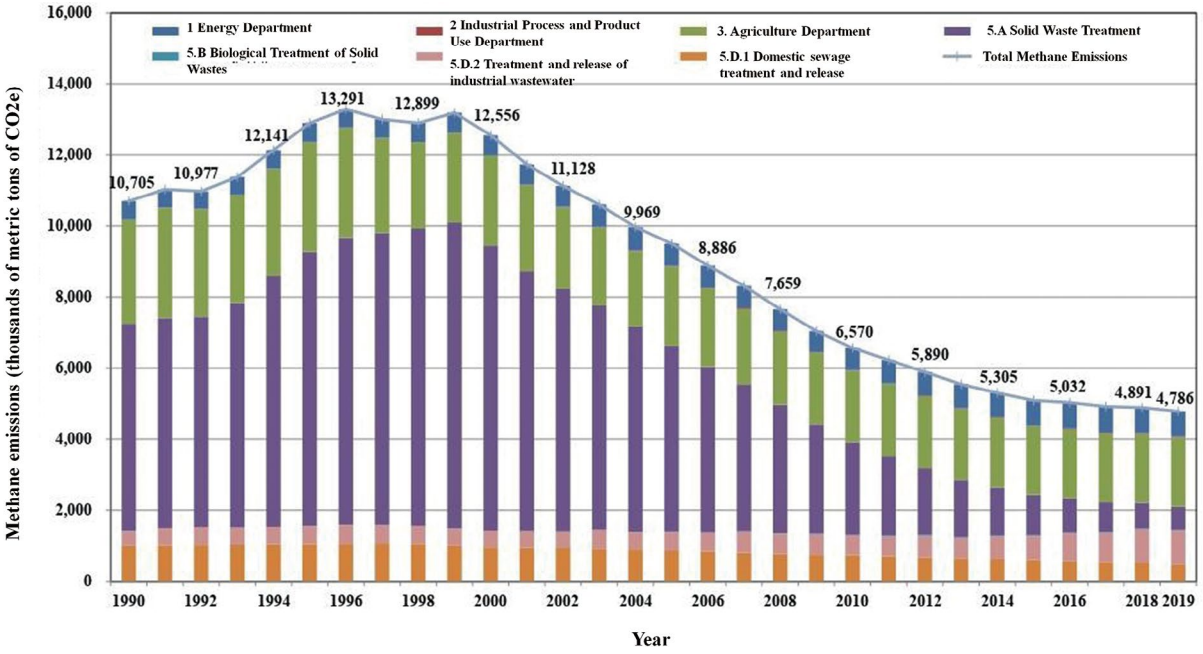

Figure 2.3.2-1 Trend of Taiwan's methane emissions from 2001 to 2019

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

In terms of the structure of resources, the waste sector accounted for the highest percentage in 2019 (43.91%), followed by the agricultural sector (40.57%), and the energy sector (14.98%). Table 2.3.2-1 shows the emissions of methane for various sectors from 1990 to 2019.

Table 2.3.2-1 Taiwan's methane emissions from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas resources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
1.Energy sector	530	533	574	631	625	622	604	597	631
2. Industrial processes and product use sector	5	10	14	18	22	28	27	21	23
3. Agricultural sector	2,914	3,079	2,511	2,228	2,197	2,116	2,056	2,006	2,003
3.A Livestock gastrointestinal fermentation	670	822	692	623	614	609	584	571	578
3.B Livestock waste treatment	1,112	1,371	1,003	957	945	888	861	825	831
3.C Rice culturing	1,094	879	802	640	630	616	604	605	589
3.F Field Burning of Agricultural Residues	38	7	14	8	8	5	6	5	5
5.Waste sector	7,257	9,277	9,457	6,631	6,042	5,553	4,972	4,420	3,913
5.A Garbage landfill	5,833	7,721	8,030	5,231	4,666	4,144	3,608	3,072	2,601
5.B Garbage biological treatment	11	1	0	10	11	14	16	18	21
5.D.1 Domestic wastewater treatment and discharge	1,001	1,046	957	865	838	805	779	755	740
5.D.2 Industrial wastewater treatment and discharge	411	509	470	526	527	589	569	575	551
Total	10,705	12,899	12,556	9,508	8,886	8,318	7,659	7,044	6,570

Greenhouse gas resources and sinks	2011	2012	2013	2014	2015	2016	2017	2018	2019
1.Energy sector	654	663	676	686	710	730	738	721	717
2. Industrial processes and product use sector	15	23	25	26	15	27	24	27	26
3. Agricultural sector	2,034	2,010	1,997	1,947	1,927	1,933	1,932	1,932	1,942
3.A Livestock gastrointestinal fermentation	590	583	579	566	573	561	564	572	575
3.B Livestock waste treatment	843	807	781	750	744	740	738	743	754
3.C Rice culturing	596	614	634	626	605	629	626	615	611
3.F Field Burning of Agricultural Residues	5	5	3	4	5	3	3	2	2
5.Waste sector	3,523	3,194	2,849	2,647	2,442	2,342	2,228	2,211	2,102
5.A Garbage landfill	2,226	1,890	1,598	1,351	1,141	970	835	723	656
5.B Garbage biological treatment	26	24	23	20	20	20	20	23	25
5.D.1 Domestic wastewater treatment and discharge	706	673	651	631	606	583	551	526	480
5.D.2 Industrial wastewater treatment and discharge	565	607	578	644	674	768	821	940	941
Total	6,226	5,890	5,547	5,305	5,093	5,032	4,922	4,891	4,786

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

2.3.3 Nitrous oxide

In terms of the overall emission trend, Taiwan's nitrous oxide emissions in 1990 were 2.992 million tons of CO2e, and the emissions increased to 4.904 million tons of CO2e in 2019, resulting in an increase of 63.91% or an average growth rate of 1.72%. The emission trend is shown in Figure 2.3.3-1.

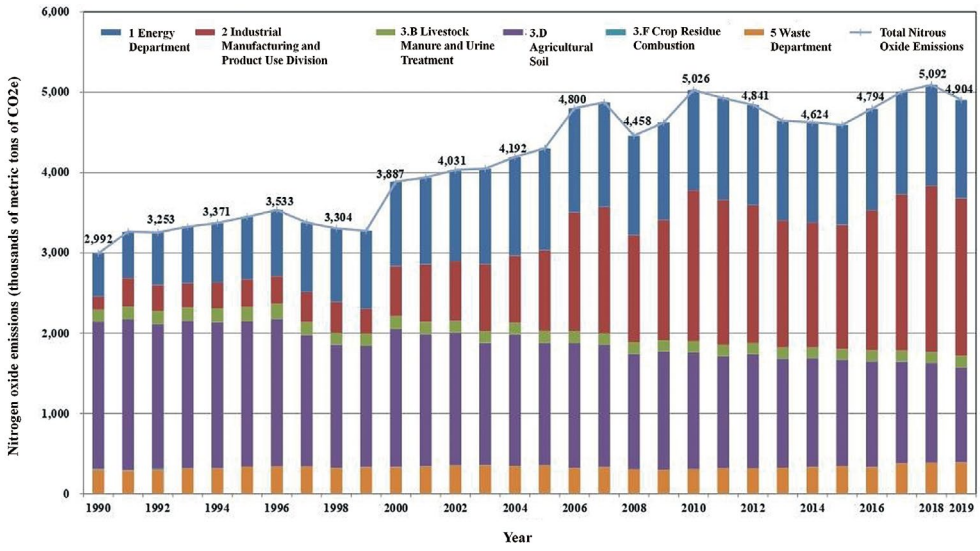

Figure 2.3.3-1 Trend of Taiwan's nitrous oxide emissions from 1990 to 2019

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

In terms of the structure of resources, the industrial processes and product use sector accounted for the highest percentage in 2019 (39.98%), followed by the agricultural sector (27.12%), and the energy sector (25.00%). Table 2.3.3-1 shows the emissions of nitrous oxide for various sectors from 1990 to 2019.

Table 2.3.3-1 Taiwan's nitrous oxide emissions from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas resources and sink	1990	1995	2000	2005	2006	2007	2008	2009	2010
1. Energy sector	537	778	1,052	1,269	1,299	1,303	1,239	1,211	1,248
1.A.1 Energy industry	138	240	428	584	612	638	616	593	603
1.A.2 Manufacturing and construction industry	90	105	134	140	145	143	131	124	135
1.A.3 Transportation	291	418	475	527	527	508	478	480	497
1.A.4 Other sectors	17	14	15	17	15	13	14	13	13
2. Industrial processes and product use sector	166	345	625	1,002	1,474	1,573	1,332	1,500	1,877
3. Agricultural sector	1,994	1,991	1,879	1,680	1,709	1,670	1,587	1,616	1,598
3.B Livestock Waste Treatment	145	180	158	153	153	146	145	141	141
3.D Agricultural soil	1,837	1,808	1,717	1,524	1,554	1,522	1,440	1,474	1,456
3.F Field Burning of Agricultural Residues	12	2	4	2	3	1	2	2	2
5.Waste sector	296	334	331	350	318	328	300	295	302
Total	2,992	3,448	3,887	4,300	4,800	4,873	4,458	4,622	5,026

Greenhouse gas resources and sink	2011	2012	2013	2014	2015	2016	2017	2018	2019
1. Energy sector	1,268	1,247	1,241	1,246	1,242	1,264	1,276	1,257	1,226
1.A.1 Energy industry	607	603	595	599	585	595	621	633	605
1.A.2 Manufacturing and construction industry	144	137	140	133	131	131	123	103	101
1.A.3 Transportation	505	495	494	500	513	526	521	510	508
1.A.4 Other sectors	12	12	12	13	13	12	12	11	11
2. Industrial processes and product use sector	1,805	1,717	1,582	1,557	1,550	1,744	1,944	2,067	1,961
3. Agricultural sector	1,540	1,564	1,497	1,490	1,459	1,456	1,406	1,385	1,330
3.B Livestock Waste Treatment	142	139	137	136	136	138	139	141	145
3.D Agricultural soil	1,396	1,424	1,359	1,353	1,322	1,318	1,266	1,243	1,184
3.F Field Burning of Agricultural Residues	2	2	1	1	1	1	1	1	1
5.Waste sector	314	313	323	332	342	330	377	383	388
Total	4,927	4,841	4,643	4,624	4,593	4,794	5,003	5,092	4,904

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

2.3.4 Hydrofluorocarbons

In terms of the overall emission trend, Taiwan's hydrofluorocarbons emissions in 1993 were 0.755 million tons of CO_2e, and the emissions increased to 1.027 million tons of CO_2e in 2019, resulting in an increase of 36.04% or an average growth rate of 1.19%. The emission trend is shown in Figure 2.3.4-1.

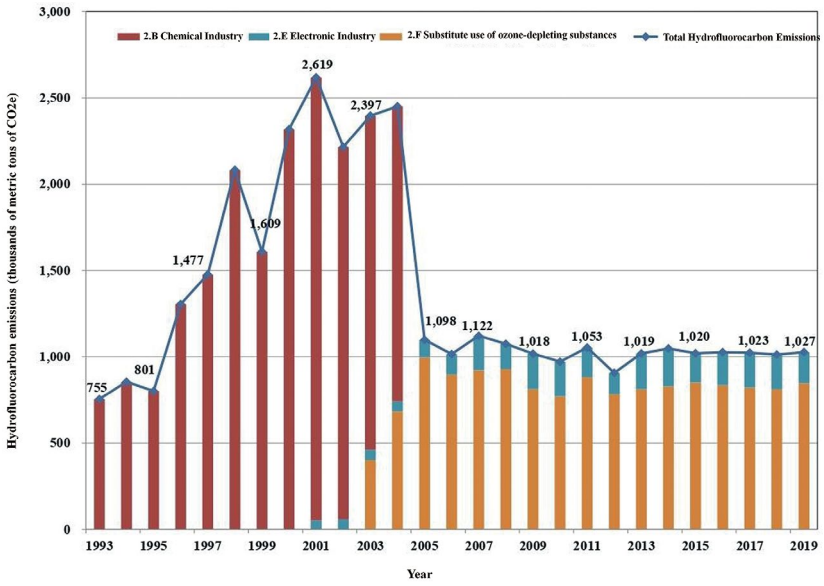

Figure 2.3.4-1 Trend of Taiwan's hydrofluorocarbons emissions from 1993 to 2019

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

In terms of the structure of resources, the industrial processes and product use sector accounted for the highest percentage. For the chemical industry, there were no hydrofluorocarbons emissions since 2005 due to the close of Taiwan's only HCFCs (Hydrochlorofluorocarbons) manufacturer (the Renwu Plant of Formosa Plastics Corporation) in 2004. In 2011, owing to the control

schedule of the Montreal Protocol, other substitutes were used for refrigeration and air conditioning, which led to the use of a significant amount of HFC-32, HFC-410A, and HFC-404A, resulting in a slight increase in their emissions. Currently, mixed refrigerants are not included in the statistics. Table 2.3.4-1 shows the emissions of hydrofluorocarbons from 1990 to 2019.

Table 2.3.4-1 Taiwan's hydrofluorocarbons emissions from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas resources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
2.B Chemical industry	NO	801	2,319	NO	NO	NO	NO	NO	NO
2.E Electronics industry	NE	NE	NE	102	119	199	146	206	201
2.F Alternatives to ozone-depleting substances	NE	NE	NE	996	896	922	928	812	770
Total	NE	801	2,319	1,098	1,015	1,122	1,074	1,018	971

Greenhouse gas resources and sinks	2011	2012	2013	2014	2015	2016	2017	2018	2019
2.B Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.E Electronics industry	172	124	207	220	170	191	202	201	181
2.F Alternatives to ozone-depleting substances	881	783	812	828	851	835	821	811	846
Total	1,053	907	1,019	1,048	1,020	1,026	1,023	1,013	1,027

Note: NO (not occurred) means that there is no production or use of the classified item in Taiwan, implying that the only HCFC plant in Taiwan operated only from 1993 to 2004.

Note: NE (not estimated) means that there is no estimate for resources and sinks.

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

2.3.5 Perfluorocarbons

In terms of the overall emission trend, Taiwan's perfluorocarbons emissions in 2001 were 2.939 million tons of CO_2e, and the emissions were reduced to 1.420 million tons of CO2e in 2019, resulting in a decrease of 51.68% or an average growth rate of -3.96%. The emission trend is shown in Figure 2.3.5-1.

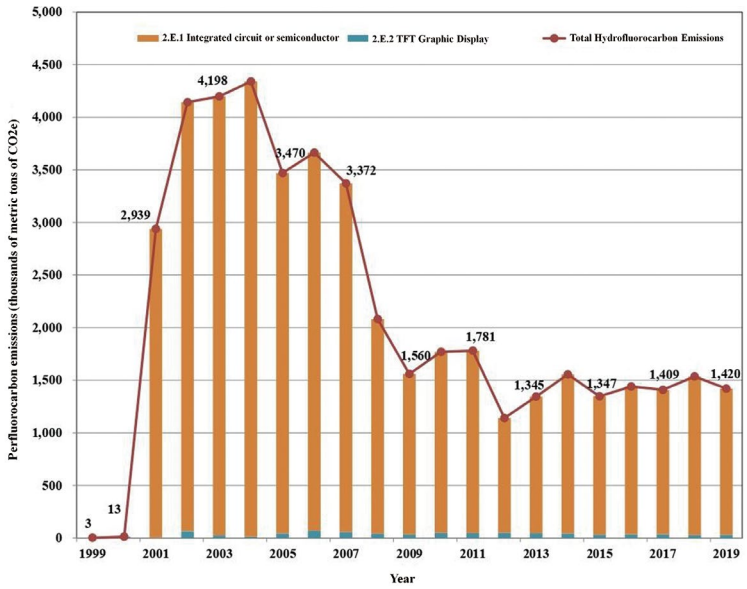

Figure 2.3.5-1 Trend of Taiwan's perfluorocarbons emissions from 1990 to 2019

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

In terms of the structure of resources, the semiconductor industry in the industrial processes and product use sector accounted for the highest percentage. In the early days, integrated circuits or semiconductors had not yet been mass-produced, and the information on perfluorocarbons emissions was not complete, making it difficult to estimate their emissions. Since 2004, the Taiwan Semiconductor Industrial Association (TSIA) has cooperated with the government of Taiwan to promote voluntary emission reduction, including the introduction and installation of exhaust gas treatment facilities in the semiconductor as well as optoelectronics industries, which help lower the emissions of perfluorocarbons year by year.

Table 2.3.5-1 Taiwan's perfluorocarbons emissions from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas resources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
2.E.1 Integrated circuit or semiconductor	NE	NE	NE	3,427	3,594	3,316	2,040	1,526	1,722
2.E.2 TFT flat-panel display	NE	NE	13	43	69	56	42	34	49
Total	NE	NE	13	3,470	3,664	3,372	2,082	1,560	1,770
Greenhouse gas resources and sinks	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
2.E.1 Integrated circuit or semiconductor	1,734	1,091	1,299	1,513	1,316	1,405	1,373	1,508	1,390
2.E.2 TFT flat-panel display	47	50	46	42	31	35	36	27	30
Total	1,781	1,141	1,345	1,556	1,347	1,441	1,409	1,536	1,420

Note: NE (not estimated) means that there is no estimate for resources and sinks.

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

2.3.6 Sulfur hexafluoride

In terms of the overall emission trend, Taiwan's sulfur hexafluoride emissions in 2002 were 3.914 million tons of CO_2e, and the emissions were reduced to 0.935 million tons of CO_2e in 2019, resulting in a decrease of 76.11% or an average growth rate -8.08%. The emission trend is shown in Figure 2.3.6-1.

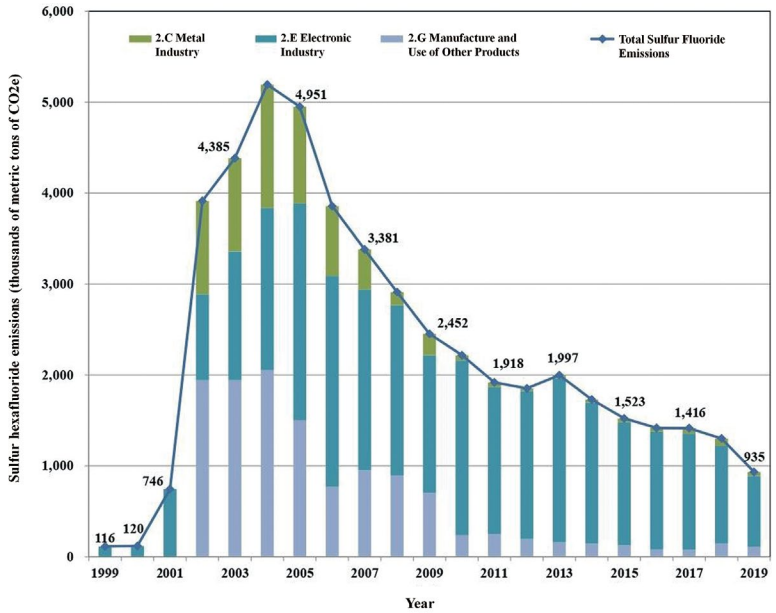

Figure 2.3.6-1 Trend of Taiwan's sulfur hexafluoride emissions from 1999 to 2019

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

In terms of the structure of resources, the electronics industry and power equipment in the industrial processes and product use sector accounted for the highest percentage. Sulfur hexafluoride emissions have increased year by year since 2002, which is due to the increase in the production and use of TFT flat-panel displays, power equipment, and magnesium. Starting with a peak of 5.193 million tons of emissions in 2004, the amount of CO_2e emissions has gradually decreased following the reduction in the use of sulfur hexaflouride as shown in Table 2.3.6-1::

Table 2.3.6-1 Taiwan's sulfur hexafluoride emissions from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas resources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
2.C Metal process	NE	NE	NE	1,063	770	440	144	235	57
2.E Electronics industry	NE	NE	120	2,384	2,318	1,988	1,872	1,514	1,923
2.G Manufacturing and use of other products	NE	NE	NE	1,503	770	953	895	703	238
Total	NE	NE	120	4,951	3,858	3,381	2,912	2,452	2,218

Greenhouse gas resources and sinks	2011	2012	2013	2014	2015	2016	2017	2018	2019
2.C Metal process	50	30	38	33	43	41	59	81	43
2.E Electronics industry	1,615	1,628	1,800	1,552	1,351	1,295	1,278	1,072	781
2.G Manufacturing and use of other products	252	195	160	146	128	82	79	149	110
Total	1,918	1,852	1,997	1,730	1,523	1,418	1,416	1,302	935

Note: NE (not estimated) means that there is no estimate for resources and sinks.

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

2.3.7 Nitrogen trifluoride

In terms of the overall emission trend, Taiwan's nitrogen trifluoride emissions in 2001 were 0.235 million tons of CO2e, and the emissions had increased to 0.473 million tons of CO2e in 2019, resulting in an increase of 101.28% or an average growth rate of 3.96%. The emission trend is shown in Figure 2.3.7-1.

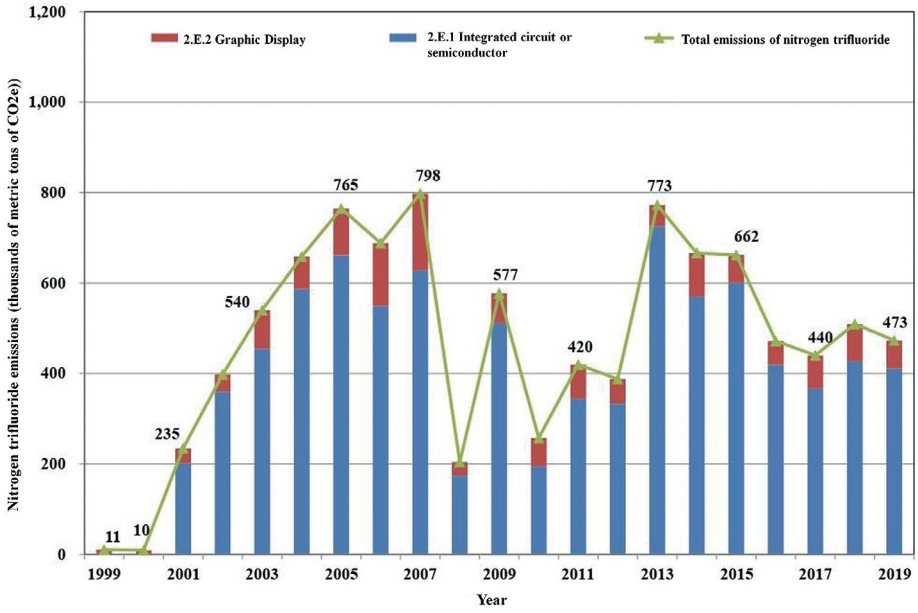

Figure 2.3.7-1 Trend of Taiwan's nitrogen trifluoride emissions from 1999 to 2019

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

In terms of the structure of resources, the semiconductor industry in the industrial processes and product use sector accounted for the highest percentage. Nitrogen trifluoride emissions have increased year by year since 2001, which is due to the increase in the use of semiconductors. By 2007, the use of semiconductors dropped sharply, resulting in a reduction in emissions in 2008. After 2012, due to the increase in the use of semiconductors and TFT flat-panel displays, nitrogen trifluoride emissions increased from 0.388 million tons of CO2e in 2012 to 0.473 million tons of CO2e in 2019.

Table 2.3.7-1 Taiwan's nitrogen trifluoride emissions from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas resources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
2.E.1 Integrated circuit or semiconductor	NE	NE	NE	661	550	628	174	512	195
2.E.2 TFT flat-panel display	NE	NE	10	104	139	170	30	66	63
Total	NE	NE	10	765	688	798	204	577	258

Greenhouse gas resources and sinks	2011	2012	2013	2014	2015	2016	2017	2018	2019
2.E.1 Integrated circuit or semiconductor	344	333	726	570	601	419	367	427	412
2.E.2 TFT flat-panel display	76	55	47	97	61	53	73	83	62
Total	420	388	773	667	662	472	440	509	473

Note: NE (not estimated) means that there is no estimate for resources and sinks.

Source: Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021

2.4 Inventory of Greenhouse Gas Emissions and Absorption Statistics by Sector

Total greenhouse gas emissions from the energy sector in 2019 were 260.662 million metric tons of carbon dioxide equivalent, representing 90.80% of total national greenhouse gas emissions. The industrial process and product use sector accounted for 20.394 million metric tons of CO_2 equivalent, or 7.10%. The agriculture sector accounted for 3.301 million metric tons of CO_2 equivalent, or 1.15%. The waste sector accounted for 2.703 million metric tons of carbon dioxide equivalent, or 0.94%. The land use, land use change and forestry sector removed 21.440 million metric tons of CO_2 equivalent. The greenhouse gas emission trends of various departments in Taiwan from 1990 to 2019 are shown in Figure 2.4.-1 and Table 2.4-1.

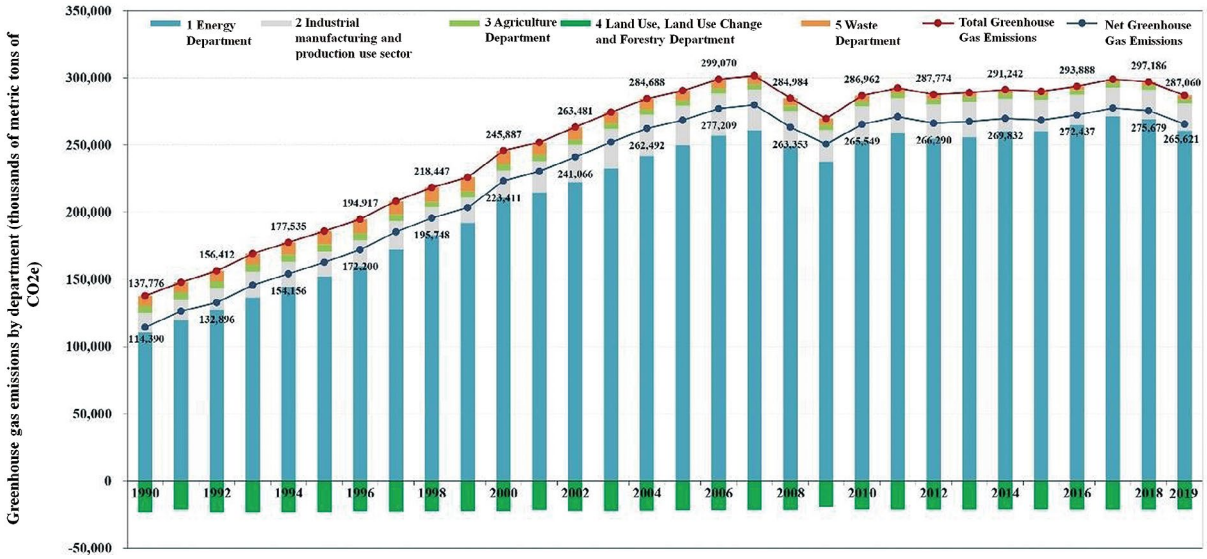

Figure 2.4-1 Trends in greenhouse gas emissions by sector in Taiwan from 1990 to 2019

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 2021

Table 2.4-1 Taiwan's greenhouse gas emissions by sector in the 1990 to 2019 inventory

Unit: 1000 tons of CO_2e

Greenhouse gas emission sources and sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Energy Department	110,525	119,521	127,202	136,414	144,365	152,115	159,917	172,206	182,961	191,966
2. Industrial process and product use sector	14,629	15,366	16,257	19,471	19,007	18,685	19,336	21,346	20,886	19,241
3. Agriculture sector	5,049	5,294	5,134	5,164	5,145	5,221	5,263	4,606	4,231	4,301
4. Land Use, Land Use Change and Forestry Sector	-23,386	-21,490	-23,516	-23,493	-23,379	-23,233	-22,717	-22,899	-22,699	-22,550
5. Waste Sector	7,573	7,709	7,818	8,214	9,018	10,009	10,399	10,245	10,370	10,493
Net Greenhouse Gas Emissions (Including LULUCF)	114,390	126,400	132,896	145,770	154,156	162,797	172,200	185,504	195,748	203,450
Total Greenhouse Gas Emissions (Excluding LULUCF)	137,776	147,890	156,412	169,263	177,535	186,030	194,917	208,403	218,447	226,000

Greenhouse gas emission sources and sinks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy Department	210,831	214,756	222,589	232,650	241,818	249,856	257,255	261,138	249,380	237,676
2. Industrial process and product use sector	20,488	23,456	27,509	29,444	30,864	29,398	31,019	30,241	26,190	23,557
3. Agriculture sector	4,521	4,320	4,189	3,944	3,981	3,969	3,966	3,844	3,700	3,678
4. Land Use, Land Use Change and Forestry Sector	-22,476	-21,583	-22,415	-22,305	-22,196	-21,918	-21,861	-21,650	-21,631	-18,911
5. Waste Sector	10,047	9,606	9,195	8,538	8,026	7,329	6,830	6,443	5,715	4,868
Net Greenhouse Gas Emissions (Including LULUCF)	223,411	230,555	241,066	252,271	262,492	268,634	277,209	280,015	263,353	250,868
Total Greenhouse Gas Emissions (Excluding LULUCF)	245,887	252,138	263,481	274,576	284,688	290,552	299,070	301,665	284,984	269,779

Greenhouse gas emission sources and sinks	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1. Energy Department	253,588	259,018	255,093	255,987	260,413	260,428	264,977	271,475	269,107	260,662
2. Industrial process and product use sector	25,296	25,977	25,397	26,270	24,228	23,336	22,684	21,456	21,979	20,394
3. Agriculture sector	3,655	3,627	3,630	3,540	3,476	3,423	3,424	3,369	3,347	3,301
4. Land Use, Land Use Change and Forestry Sector	-21,413	-21,470	-21,484	-21,499	-21,410	-21,425	-21,451	-21,486	-21,507	-21,440
5. Waste Sector	4,423	3,986	3,655	3,325	3,125	2,886	2,804	2,734	2,754	2,703
Net Greenhouse Gas Emissions (Including LULUCF)	265,549	271,137	266,290	267,623	269,832	268,648	272,437	277,549	275,679	265,621
Total Greenhouse Gas Emissions (Excluding LULUCF)	286,962	292,607	287,774	289,121	291,242	290,073	293,888	299,034	297,186	287,060

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 2021

The greenhouse gas emission profile of each department is described as follows.

2.4.1 Energy Sector

The types of greenhouse gas emissions from Taiwan's energy sector include carbon dioxide, methane, and nitrous oxide. The total GHG emissions of the sector showed an upward trend over the years, with the first downward trend in 2008, and then again in 2009, 2012, and 2018, with a decrease of 3.14% in 2019 compared to 2018, as shown in Table 2.4.1-1 and Figure 2.4.1-2.

The total greenhouse gas emissions from the energy sector in 2019 were 260.662 million metric tons of carbon dioxide equivalent, accounting for approximately 90.80% of Taiwan's total greenhouse gas emissions. "Fuel combustion activities" accounted for 260.405 million metric tons of CO2-equivalent, representing the bulk of the Energy Sector's total greenhouse gases, or approximately 99.90%, and "fuel fugitive emissions" accounted for 0.258 million metric tons of CO_2-equivalent, or 0.1%. 1.A.1 "Energy Industry" was 182.014 million metric tons of CO2 equivalent, accounting for 69.83% of total GHG emissions from the energy sector; 1.A.2"Manufacturing and construction industry" was 32.797 million metric tons of CO_2 equivalent (12.58%); 1.A.3 "Transportation" was 36.238 million metric tons of CO2 equivalent (13.90%); 1.A.4 "Other sectors (including services, residential, agriculture, forestry, and fishery)" was 9.356 million metric tons of CO2 equivalent (3.59%).

Between 1990 and 2019, greenhouse gas emissions from the energy sector grew by 135.84%, with an average annual growth rate of 3.00%, of which 1.A.1 "Energy industry" greenhouse gas emissions increased by 269.29% (an average annual growth rate of 4.61%); 1.A.2"Manufacturing and construction industry" increased by 8.41% (an average annual growth rate of 0.28%); 1.A.3 "Transportation" increased by 80.39% (an average annual growth rate of 2.06%); 1.A.4 "Other Sectors" decreased by 11.90% (an average annual growth rate of -0.44%); and 1.B.2 "Oil & Gas" increased by 124.81% (an average annual growth rate of 2.83%).

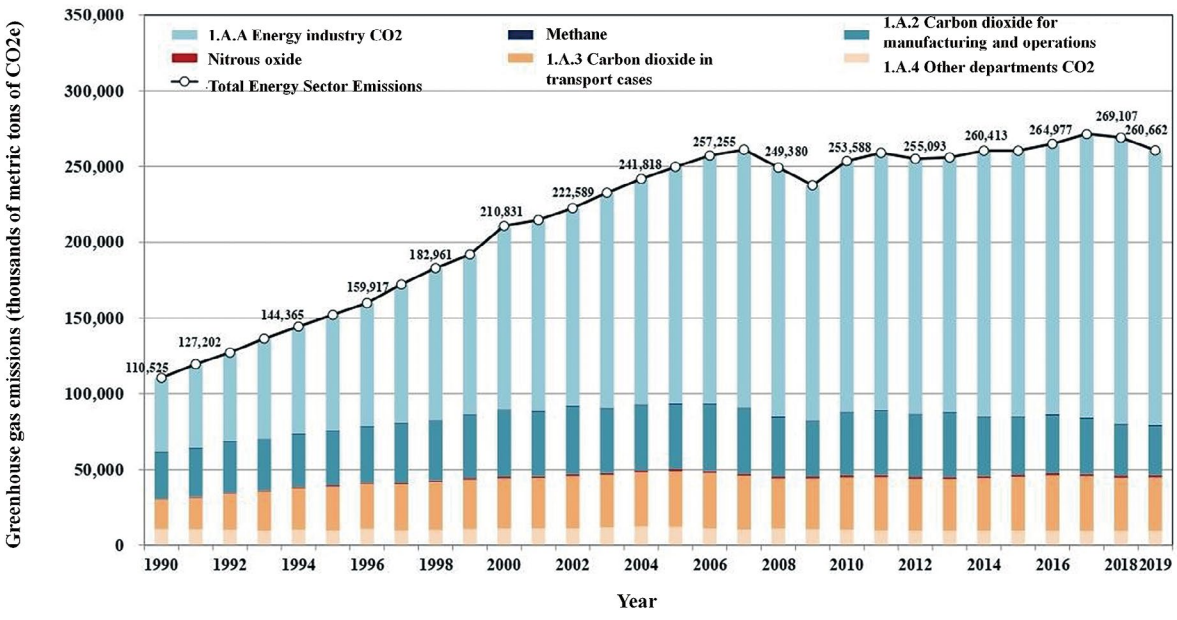

Figure 2.4.1-1 Trends in greenhouse gas emissions by energy sector in Taiwan from 1990 to 2019

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 2021

Table 2.4.1-1 Greenhouse gas emissions by energy sector in Taiwan from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas emission sources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
Total carbon dioxide emissions	109,459	150,803	209,205	247,956	255,331	259,214	247,537	235,868	251,708
1.A.1 Energy Industry	49,123	76,400	121,143	156,351	163,615	170,131	164,432	155,166	165,522
1.A.2 Manufacturing and construction industry	30,117	35,763	43,934	42,671	43,994	43,293	39,104	36,698	41,360
1.A.3 Transportation	19,646	28,822	33,207	36,846	36,771	35,419	33,216	33,541	34,652
1.A.4 Others sectors	10,572	9,819	10,922	12,089	10,952	10,370	10,785	10,463	10,174
Total Methane Emissions	530	533	574	631	625	622	604	597	631
1.A.1 Energy Industry	26	40	66	84	88	90	88	81	86
1.A.2 Manufacturing and Operations	46	54	70	75	78	77	71	67	74
1.A.3 Transportation	152	228	270	303	298	289	275	281	284
1.A.4 Other Departments	30	27	29	33	29	27	28	27	26
1.B.1 Solid Fuels	162	81	28	NO	NO	NO	NO	NO	NO
1.B.2 Oil and Natural Gas	115	103	111	137	133	138	142	141	161
Total Nitrous Oxide Emissions	537	778	1,052	1,269	1,299	1,303	1,239	1,211	1,248
1.A.1 Energy Industry	138	240	428	584	612	638	616	593	603
1.A.2 Manufacturing and Operations	90	105	134	140	145	143	131	124	135
1.A.3 Transportation	291	418	475	527	527	508	478	480	497
1.A.4 Other Departments	17	14	15	17	15	13	14	13	13
Total emission from energy sector	110,525	152,115	210,831	249,856	257,255	261,138	249,380	237,676	253,588

Greenhouse gas emission sources and sinks	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total carbon dioxide emissions	257,096	253,183	254,070	258,481	258,476	262,982	269,462	267,129	258,719
1.A.1 Energy Industry	169,884	168,333	168,271	175,180	175,198	178,569	187,135	189,212	181,318
1.A.2 Manufacturing and construction industry	42,298	41,000	42,019	38,953	38,074	38,296	36,741	33,401	32,638
1.A.3 Transportation	35,107	34,284	34,209	34,666	35,506	36,584	36,202	35,207	35,443
1.A.4 Others sectors	9,807	9,566	9,571	9,681	9,698	9,533	9,384	9,310	9,320
Total Methane Emissions	654	663	676	686	710	730	738	721	717
1.A.1 Energy Industry	86	86	85	88	91	92	94	94	90
1.A.2 Manufacturing and Operations	79	76	78	74	74	74	69	59	58
1.A.3 Transportation	287	283	284	285	292	301	295	286	287
1.A.4 Other Departments	25	25	25	25	25	25	24	24	24
1.B.1 Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.B.2 Oil and Natural Gas	176	193	205	214	228	239	255	258	258
Total Nitrous Oxide Emissions	1,268	1,247	1,241	1,246	1,242	1,264	1,276	1,257	1,226
1.A.1 Energy Industry	607	603	595	599	585	595	621	633	605
1.A.2 Manufacturing and Operations	144	137	140	133	131	131	123	103	101
1.A.3 Transportation	505	495	494	500	513	526	521	510	508
1.A.4 Other Departments	12	12	12	13	13	12	12	11	11
Total emission from energy sector	259,018	255,093	255,987	260,413	260,428	264,977	271,475	269,107	260,662

Description: NO (did not occur). Taiwan coal has been out of production since 2001.

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 2021

2.4.2 Industrial Process and Product Use Sector

The types of greenhouse gases emitted by Taiwan's industrial processes and product use sectors include carbon dioxide, methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons, sulfur hexafluoride, and nitrogen trifluoride. The department's historical greenhouse gas emissions are shown in Figure 2.4.2-1 and Table 2.4.2-1.

In 2019, total GHG emissions from industrial processes and product use sectors amounted to 20.394 million metric tons of CO_2 equivalent, accounting for approximately 7.10% of Taiwan's total GHG emissions, of which 2.A "Mining industry (non-metal products)" accounted for 31.88% of CO_2 emissions, accounting for the largest proportion, followed by 2.C "Metal process" CO_2 emissions accounting for 31.44% of GHG emissions from industrial process sectors, 2.B "chemical industry" CO_2 emissions accounting for 8.17%. B "chemical industry" accounted for 8.17% of CO_2 emissions.

Between 1990 and 2019, industrial processes and products using greenhouse gas emissions increased by 39.41% (an average annual growth rate of 1.15%).

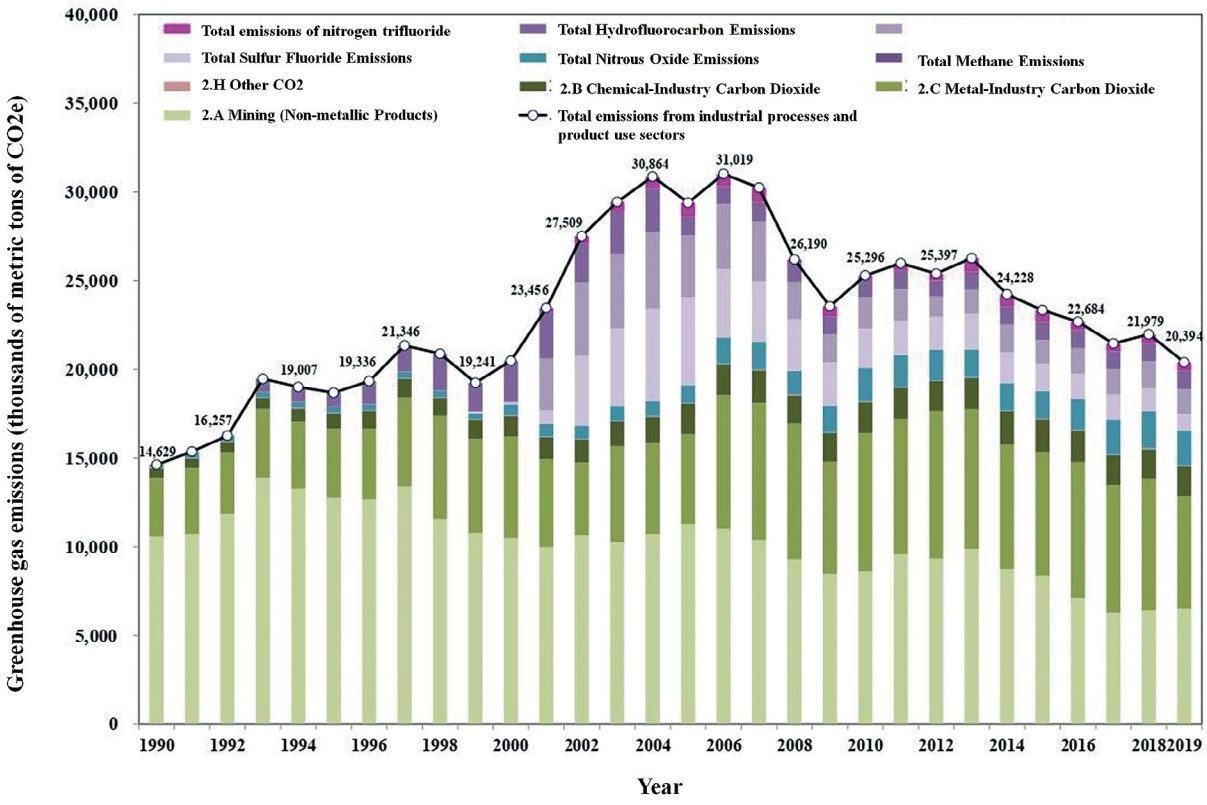

Figure 2.4.2-1 Trends in greenhouse gas emissions from industrial processes and product use sectors in Taiwan from 1990 to 2019

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 2021

Table 2.4.2-1 Taiwan's greenhouse gas emissions from industrial processes and product use sectors from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas emission sources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
Total carbon dioxide emissions	14,458	17,528	17,388	18,094	20,299	19,967	18,558	16,428	18,178
2.A Mining industry (non-metal products)	10,584	12,766	10,486	11,257	11,014	10,369	9,289	8,467	8,616
2.B Chemical Industry	575	858	1,148	1,751	1,721	1,845	1,601	1,623	1,750
2.C Metal Industry	3,275	3,884	5,734	5,066	7,544	7,733	7,648	6,317	7,792
2.H Others	23	21	20	20	21	20	20	21	20
Total Methane Emissions	5	10	14	18	22	28	27	21	23
Total Nitrous Oxide Emissions	166	345	625	1,002	1,474	1,573	1,332	1,500	1,877
2.B Chemical Industry	166	345	625	960	969	996	784	1,006	1,170
2.C Metal Industry	NE	NE	NE	0	94	95	90	76	119
2.E Electronic Industry	NE	NE	NE	42	411	481	458	417	588
Total Hydrofluorocarbon Emissions	NE	801	2,319	1,098	1,015	1,122	1,074	1,018	971
2.B Chemical Industry	NE	801	2,319	NE	NE	NE	NE	NE	NE
2.E Electronic Industry	NE	NE	NE	102	119	199	146	206	201
2.F Alternatives to ozone-depleting substances	NE	NE	NE	996	896	922	928	812	770
Total Perfluorocarbon Emissions (2.E Electronic Industry)	NE	NE	13	3,470	3,664	3,372	2,082	1,560	1,770
Total Sulfur Fluoride Emissions	NE	NE	120	4,951	3,858	3,381	2,912	2,452	2,218
2.C Metal Industry	NE	NE	NE	1,063	770	440	144	235	57
2.E Electronic Industry	NE	NE	120	2,384	2,318	1,988	1,872	1,514	1,923
2.G Manufacturing and use of other products	NE	NE	NE	1,503	770	953	895	703	238
Total Emissions of Nitrogen Trifluoride (2.E Electronic Industry)	NE	NE	10	765	688	798	204	577	258
Total emission from industrial process and product use sector	14,629	18,685	20,488	29,398	31,019	30,241	26,190	23,557	25,296

Greenhouse gas emission sources and sinks	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total carbon dioxide emissions	18,985	19,369	19,529	17,644	17,219	16,557	15,199	15,525	14,553
2.A Mining industry (non-metal products)	9,577	9,333	9,866	8,728	8,345	7,108	6,262	6,403	6,501
2.B Chemical Industry	1,768	1,714	1,749	1,884	1,854	1,760	1,709	1,684	1,666
2.C Metal Industry	7,620	8,301	7,894	7,013	7,000	7,670	7,208	7,419	6,368
2.H Others	20	21	19	19	20	19	20	19	17
Total Methane Emissions	15	23	25	26	15	27	24	27	26
Total Nitrous Oxide Emissions	1,805	1,717	1,582	1,557	1,550	1,744	1,944	2,067	1,961
2.B Chemical Industry	1,195	1,016	780	728	691	961	1,114	1,110	931
2.C Metal Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E Electronic Industry	611	701	802	829	860	783	830	957	1,030
Total Hydrofluorocarbon Emissions	1,053	907	1,019	1,048	1,020	1,026	1,023	1,013	1,027
2.B Chemical Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E Electronic Industry	172	124	207	220	170	191	202	201	181
2.F Alternatives to ozone-depleting substances	881	783	812	828	851	835	821	811	846
Total Perfluorocarbon Emissions (2.E Electronic Industry)	1,781	1,141	1,345	1,556	1,347	1,441	1,409	1,536	1,420
Total Sulfur Fluoride Emissions	1,918	1,852	1,997	1,730	1,523	1,418	1,416	1,302	935
2.C Metal Industry	50	30	38	33	43	41	59	81	43
2.E Electronic Industry	1,615	1,628	1,800	1,552	1,351	1,295	1,278	1,072	781
2.G Manufacturing and use of other products	252	195	160	146	128	82	79	149	110
Total Emissions of Nitrogen Trifluoride (2.E Electronic Industry)	420	388	773	667	662	472	440	509	473
Total emission from industrial process and product use sector	25,977	25,397	26,270	24,228	23,336	22,684	21,456	21,979	20,394

Description: NE (not estimated) means that there is no estimate of existing emissions by sources and removals by sinks.

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 2021

2.4.3 Agricultural Sector

The types of greenhouse gases emitted by Taiwan's agricultural sector include methane, nitrous oxide, and a small amount of carbon dioxide. In 2019, a total of 3.301 million metric tons of carbon dioxide equivalent were emitted, accounting for about 1.15% of Taiwan's total GHG emissions, of which 3.D "agricultural soil" nitrous oxide emissions account for 35.88% of GHG emissions from the agricultural sector, accounting for the largest proportion, followed by 3.B "livestock manure and urine treatment" accounting for 27.23%, 3.C "rice cultivation" methane emissions accounting for 18.51%, and 3.A "livestock gastrointestinal fermentation" accounted for 17.41% of methane emissions, as shown in Figure 2.4.3-1 and Table 2.4.3-1.

Between 1990 and 2019, greenhouse gas emissions from the agricultural sector were reduced by about 34.63% (average annual growth rate of -1.46%), with 3.D "agricultural soils" greenhouse gas reduction being the largest, followed by 3.C "rice cultivation" and 3.B "livestock manure and urine treatment."

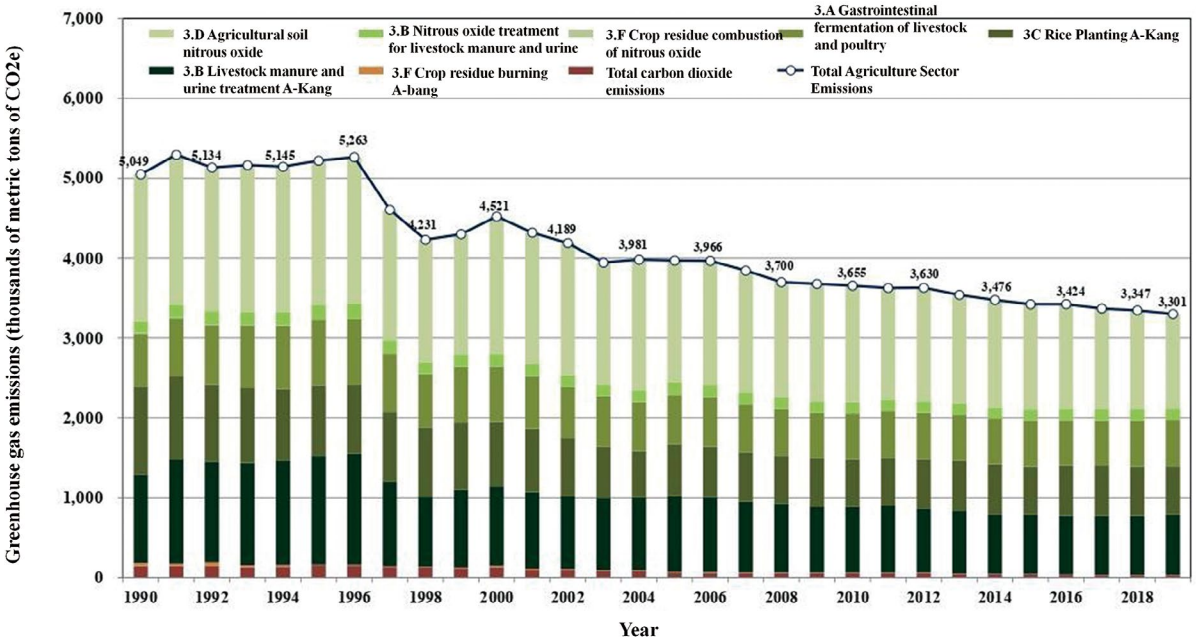

Figure 2.4.3-1 Trends in greenhouse gas emissions by agriculture sector in Taiwan from 1990 to 2019

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 2021

Table 2.4.3-1 Greenhouse gas emissions by agriculture sector in Taiwan from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas emission sources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
Total carbon dioxide emissions	142	151	131	62	59	57	57	55	54
Total Methane Emissions	2,914	3,079	2,511	2,228	2,197	2,116	2,056	2,006	2,003
3.A Livestock gastrointestinal fermentation	670	822	692	623	614	609	584	571	578
3.B Livestock waste treatment	1,112	1,371	1,003	957	945	888	861	825	831
3.C Rice culturing	1,094	879	802	640	630	616	604	605	589
3.F Field Burning of Agricultural Residues	38	7	14	8	8	5	6	5	5
Total Nitrous Oxide Emissions	1,994	1,991	1,879	1,680	1,709	1,670	1,587	1,616	1,598
3.B Livestock Manure and Urine Treatment	145	180	158	153	153	146	145	141	141
3.D Agricultural Soil	1,837	1,808	1,717	1,524	1,554	1,522	1,440	1,474	1,456
3.F Crop Residue Combustion	12	2	4	2	3	1	2	2	2

Greenhouse gas emission sources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
Total emission from agriculture sector	5,049	5,221	4,521	3,969	3,966	3,844	3,700	3,678	3,655

Greenhouse gas emission sources and sinks	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total carbon dioxide emissions	53	55	45	40	38	34	31	30	29
Total Methane Emissions	2,034	2,010	1,997	1,947	1,927	1,933	1,932	1,932	1,942
3.A Livestock gastrointestinal fermentation	590	583	579	566	573	561	564	572	575
3.B Livestock waste treatment	843	807	781	750	744	740	738	743	754
3.C Rice culturing	596	614	634	626	605	629	626	615	611
3.F Field Burning of Agricultural Residues	5	5	3	4	5	3	3	2	2
Total Nitrous Oxide Emissions	1,540	1,564	1,497	1,490	1,459	1,456	1,406	1,385	1,320
3.B Livestock Manure and Urine Treatment	142	139	137	136	136	138	139	141	145
3.D Agricultural Soil	1,396	1,424	1,359	1,353	1,322	1,318	1,266	1,243	1,184
3.F Crop Residue Combustion	2	2	1	1	1	1	1	1	1
Total emission from agriculture sector	3,627	3,630	3,540	3,476	3,423	3,424	3,369	3,347	3,301

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 2021

2.4.4 Land Use, Land Use Change and the Forestry Sector

Carbon dioxide is the main greenhouse gas displaced by the land use and forestry sector. The number of removals over the years has shown a slight up and down trend. The annual amount of removals does not vary significantly, mainly due to the increase in removals from the annual growth of forest resources, while the increase in removals from afforestation and the decrease in removals from forest disturbance remain relatively small. The total absorption in 2019 is 21.440 million metric tons of CO_2 equivalent, which is 8.32% lower than the removal in 1990 (23.386 million metric tons of CO_2 equivalent), and the trend is relatively stable. In 1991 and 2001, the amount of carbon loss due to forest fires and typhoons was high, and in 2009, Typhoon Morakot caused serious damage to Taiwan, resulting in a large volume of forest wood loss, with the annual removal amount being the lowest ever. As shown in Figure 2.4.4-1 and Table 2.4.4-1.

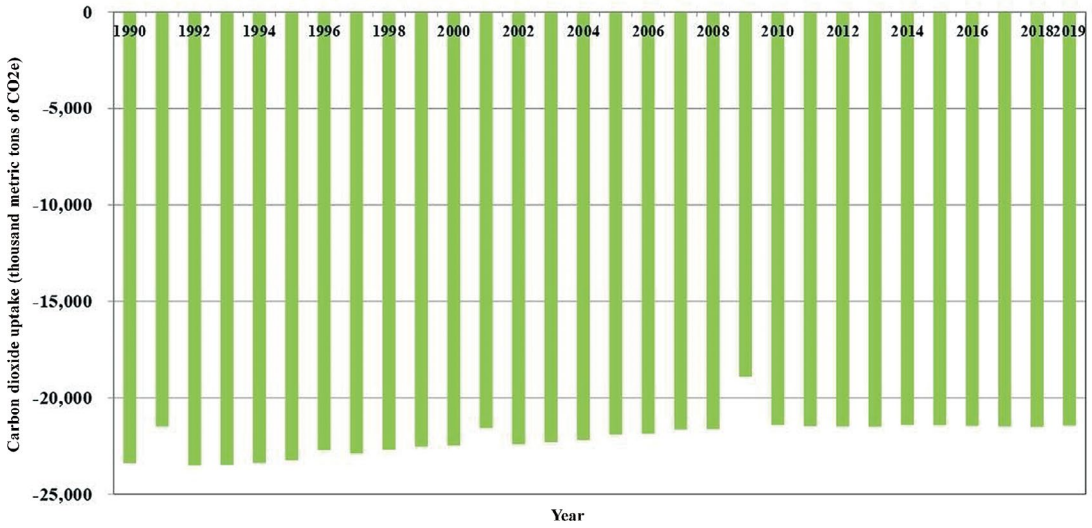

Figure 2.4.4-1 Trends in land use, land use change, and carbon removal in the forestry sector in Taiwan from 1990 to 2019

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 202

Table 2.4.4-1 Land Use, Land Use Change, and Greenhouse Gas Emissions from the Forestry Sector, Taiwan, 1990-2019

Unit: 1000 tons of CO_2e

Greenhouse gas emission sources and sinks		1990	1995	2000	2005	2006	2007	2008	2009	2010
4.A.1 Forests Maintaining Forests	Biomass Carbon Sequestration (△ CO_2G)	-23,902	-23,146	-22,201	-21,255	-21,066	-20,877	-20,688	-20,499	-20,392
	Biomass Carbon Emissions (△ CO_2L)	607	202	389	369	251	308	199	2,753	218
4.A.2 Other Lands Turned to Forests	Biomass Carbon Removal (△ CO_2G)	-91	-288	-665	-1,032	-1,046	-1,080	-1,142	-1,166	-1,240
Total Carbon Sequestration (△ CO_2)		-23,386	-23,233	-22,476	-21,918	-21,861	-21,650	-21,650	-18,911	-21,413

Greenhouse gas emission sources and sinks		2011	2012	2013	2014	2015	2016	2017	2018	2019
4.A.1 Forests Maintaining Forests	Biomass Carbon Sequestration (△ CO_2G)	-20,409	-20,435	-20,473	-20,508	-20,546	-20,575	-20,612	-20,656	-20,710
	Biomass Carbon Emissions (△ CO_2L)	140	145	135	197	189	153	107	83	116

Greenhouse gas emission sources and sinks		2011	2012	2013	2014	2015	2016	2017	2018	2019
4.A.2 Other Lands Turned to Forests	Biomass Carbon Removal (△ CO_2G)	-1,202	-1,194	-1,161	-1,099	-1,068	-1,029	-980	-934	-845
Total Carbon Sequestration (△ CO_2)		-21,470	-21,484	-21,499	-21,410	-21,425	-21,451	-21,486	-21,507	-21,440

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 2021

2.4.5 Waste Sector

The types of greenhouse gases emitted by the waste sector include carbon dioxide, methane, and nitrous oxide, with emissions of 2.703 million metric tons of carbon dioxide equivalent in 2019, accounting for 0.94% of Taiwan's total greenhouse gas emissions. 5.D "Wastewater Treatment and Discharge" accounted for 52.58% of the GHG emissions from the waste sector, making up the largest proportion, followed by 5.A "Garbage landfill" emissions accounting for 24.26%.

Between 1990 and 2019, GHG emissions from the waste sector decreased by about 64.30% (with an average annual growth rate of -3.49%). As shown in Figure 2.4.5-1 and Table 2.4.5-1.

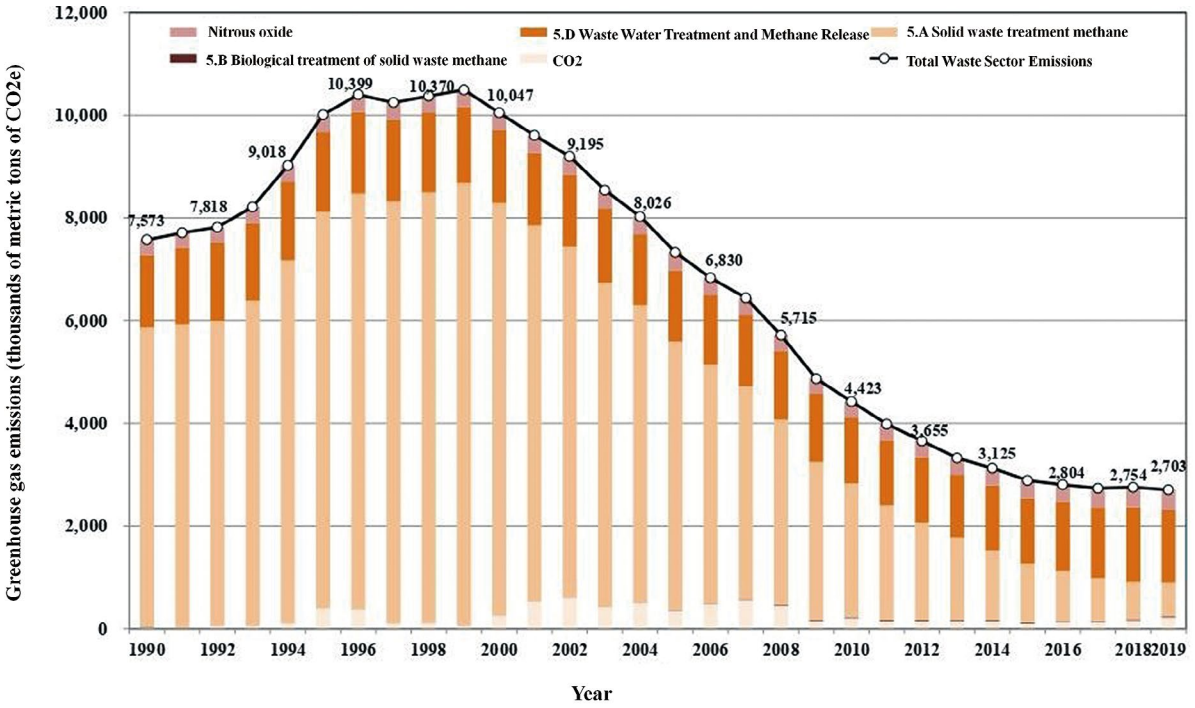

Figure 2.4.5-1 Trends in greenhouse gas emissions by waste sector in Taiwan from 1990 to 2019

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 2021

Table 2.4.5 -1 Taiwan's greenhouse gas emissions by the waste sector from 1990 to 2019

Unit: 1000 tons of CO_2e

Greenhouse gas emission sources and sinks	1990	1995	2000	2005	2006	2007	2008	2009	2010
Total carbon dioxide emissions	20	398	259	348	470	562	443	154	208
Total Methane Emissions	7,257	9,277	9,457	6,631	6,042	5,553	4,972	4,420	3,913
5.A Garbage landfill	5,833	7,721	8,030	5,231	4,666	4,144	3,608	3,072	2,601
5.B Garbage biological treatment	11	1	0	10	11	14	16	18	21
5.D Wastewater Treatment and Discharge	1,412	1,555	1,427	1,391	1,365	1,395	1,348	1,330	1,290
Total Nitrous Oxide Emissions	296	334	331	350	318	328	300	295	302
5.B Biological Treatment of Solid Wastes	10	1	0	9	10	13	15	16	19
5.C Incineration and Open Burning of Waste	1	18	8	27	30	30	21	9	11
5.D Wastewater Treatment and Release	284	316	322	314	278	285	264	270	273
Total emission from waste sector	7,573	10,009	10,047	7,329	6,830	6,443	5,715	4,868	4,423

Greenhouse gas emission sources and sinks	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total carbon dioxide emissions	149	149	153	146	103	132	129	159	214
Total Methane Emissions	3,523	3,194	2,849	2,647	2,442	2,342	2,228	2,211	2,102
5.A Garbage landfill	2,226	1,890	1,598	1,351	1,141	970	835	723	656
5.B Garbage biological treatment	26	24	23	20	20	20	20	23	25
5.D Wastewater Treatment and Discharge	1,271	1,279	1,228	1,275	1,281	1,352	1,373	1,465	1,421
Total Nitrous Oxide Emissions	314	313	323	332	342	330	377	383	388
5.B Biological Treatment of Solid Wastes	23	22	20	18	18	18	18	21	22
5.C Incineration and Open Burning of Waste	9	9	9	9	6	7	7	7	8
5.D Wastewater Treatment and Release	282	282	294	305	318	306	352	356	358
Total emission from waste sector	3,986	3,655	3,325	3,125	2,886	2,804	2,734	2,754	2,703

Source: EPA, "National Greenhouse Gas Emissions Inventory Report of the Republic of China (2021 Edition)," 2021

2.5 Greenhouse Gas Key Sources and Trend Analysis

In terms of key sources of greenhouse gas emissions, the energy sector has been the largest emitter of total greenhouse gas emissions in Taiwan over the years. GHG emissions from the energy sector accounted for approximately 80.22%, 85.99%, and 90.80% of total emissions (excluding LULUCF) in 1990, 2005, and 2019 respectively; the industrial processes and product use sector accounted for 10.62%, 10.12%, and 7.10%; the agriculture sector accounted for 3.66%, 1.37%, and 1.15%; and the waste sector accounted for 5.50%, 2.52%, and 0.94%.

In the analysis of emission trends, the increase in 2019 compared to 1990 was 108.35%, with an increase of 135.84% in the energy sector, 39.41% in the industrial processes and product use sector, 34.62% in the agriculture sector, 64.31% in the waste sector, and 8.32% in the land use, land use change and forestry sector for removals.

The decrease in 2019 compared to 2005 is 1.20%, with an increase of 4.32% in the energy sector. The decrease is 30.63% in the industrial processes and product use sector, 16.83% in the agriculture sector, 63.12% in the waste sector, and 2.18% in the land use, land use change, and forestry sector for removals.

Reference

1. Environmental Protection Administration, Executive Yuan, "2021 National Greenhouse Gas Inventory Report of the Republic of China," 2021: https://unfccc.saveoursky.org.tw/nir/tw_nir_2021.php.

Chapter 3

Greenhouse Gas Reduction Policies and Measures in Taiwan

3.1 Taiwan's position in fighting against climate change

3.2 The governance structure for climate change

3.3 Greenhouse gas reduction policies and measures

Chapter 3 Greenhouse Gas Reduction Policies and Measures in Taiwan

Taiwan follows the spirit and principles of UNFCCC (United Nations Framework Convention on Climate Change) to establish a sound climate governance framework, implement various greenhouse gas reduction policies as well as measures, and actively promote international collaboration. In the face of increasing climate challenges, President Tsai Ing-wen announced on New Year's Day in 2021 that the government will take the initiative to engage in dialogue with all walks of life to seek the pathway that is most suitable for future sustainable development and convert the challenges of carbon reduction into new opportunities for industrial investment and job creation, finding a new direction for the sustainable development of Taiwan.

This Chapter explains Taiwan's governance structure for climate change and summarizes the important reduction policies and measures promoted by the central government, the six major sectors (energy sector, manufacturing sector, transportation sector, residential and commercial sector, agricultural, and environmental sector) and local governments at different levels.

3.1 Taiwan's position in fighting against climate change

Since Taiwan officially announced the promotion of meaningful participation in the UNFCCC in 2009, it has endeavored to attend the UNFCCC Conference of Parties (COP) as an "observer" and has followed the spirit and principles of UNFCCC to continuously issue and update the National Communication, the National Greenhouse Gas Inventory Report, and the "Intended Nationally Determined Contribution (INDC)." In addition, Taiwan continues to participate in UNFCCC conferences and activities, keeping updated with the rapidly changing international regulations on climate change and carbon reduction and the latest development trend. By adhering to the principle of "using sincere friendship as the foundation to build substantial collaborative relations with other countries," Taiwan propagates its efforts and achievements in fighting against climate change in a diversified and timely manner, interacting with representatives of friendly countries and international organizations, and continuously accumulating assistance from all over the world that supports Taiwan's participation in the UNFCCC.

Measures to fight against climate change have been actively implemented in Taiwan. In 2015, the "Greenhouse Gas Reduction and Management Act" was passed, confirming Taiwan's strategic framework for promoting climate actions. In 2016, the Office of Energy and Carbon Reduction was established by the Executive Yuan to coordinate national energy policies and promote energy transformation as well as greenhouse gas emission reduction. In view of the global trend towards net-zero emissions that has gradually taken shape in recent years, President Tsai Ing-wen announced on January 1, 2021, that the government would actively engage in dialogue with all walks of life to chart the pathway of Taiwan's climate governance. She also announced on Earth Day on April 22 that Taiwan's next step is to work towards the goal of "Net-Zero Emissions by 2050." On the same day, premier Su Tseng-chang also ruled that Taiwan's "Greenhouse Gas Reduction and Management Act" must aim for the goal of Net-Zero Emissions by 2050 and officially incorporated the "Net-Zero Emissions by 2050" into the amendment process in August.

Under the coordination of the Executive Yuan, the government has begun to assess and plan possible pathways for Taiwan to achieve the goal of Net-Zero Emissions by 2050 and seek ways to respond to the challenges of climate change from the perspectives of industry, environment, government governance, and national security, finding new opportunities for the industries. In the process of formulating the pathways, the importance of social communication was also considered. In addition, the Environmental Protection Administration, Executive Yuan, also took into consideration the goal of net-zero emissions while carrying out the amendment of the "Greenhouse Gas Reduction and Management Act." It also actively conducted communications and evaluations on issues such as the promotion of carbon tax and special funds for mitigating climate change. A comprehensive plan for carbon reduction was formulated, hoping to transform the challenge of carbon reduction into new opportunities for the industries and employment.

3.2 The governance structure for climate change

Given that climate change issues have both cross-regional and cross-domain characteristics, the promotion of climate policies highly relies on the coordination between various ministries and departments, as well as the collaboration between central and local governments. In terms of the organizational structure of the government, it is essential to establish a climate policy promotion mechanism that is coordinated by the Executive Yuan and based on the division of authority and responsibilities of various ministries/departments. As for laws and policies, the "Greenhouse Gas Reduction and Management Act (hereinafter referred to as the "Greenhouse Gas Management Act")" can be used as the framework for coordinating Taiwan's climate actions as well as other energy- related laws and regulations, providing more comprehensive control tools and economic incentives for climate actions.

3.2.1 Organizational structure of the government

The Executive Yuan has established the "Climate Change and Carbon Reduction Task Force" and the "Office of Energy and Carbon Reduction" under the National Council for Sustainable Development to coordinate the implementation of sustainability, energy transformation, and greenhouse gas reduction-related tasks in Taiwan. To further fulfill the authority and responsibilities of various ministries/departments in promoting climate change-related policies, the Greenhouse Gas Management Act clearly states that the Environmental Protection Administration, Executive Yuan is the central competent authority. In addition, an inter-departmental promotion mechanism for the management of greenhouse gas reduction and the hierarchy of responsibility for the central and local governments were established. The following describes the main organizational structure of the government for promoting climate change policies in Taiwan:

1. "Climate Change and Carbon Reduction Task Force" of the National Council for Sustainable Development

(1) Introduction

To comply with the global trend, the "Working Committee on Global Environmental Change Policy" was established in August 1994, which was composed of the heads of relevant ministries/departments and experts. It consisted of six working groups in response to environmental issues worldwide as well as sustainable development and was expanded to form the "National Council for Sustainable Development (hereinafter referred to as the NCSD)" in 1997. The Minister without Portfolio of the Executive Yuan was appointed as the Chairman of the NCSD, while the secretary and staff-related work was performed by the Environmental Protection Administration, which was then handed over to the National Development Council in August 2021. In November 2002, the Legislative Yuan passed the "Basic Environment Act" and Article 29 of which gave NCSD a legal status, upgrading the NCSD from a task force to a statutory council.

(2) Organizational structure

To promote the 18 major goals of sustainable development in Taiwan, the NCSD has established a "Climate Change and Carbon Reduction Task Force" for handling energy transformation, carbon reduction, and climate change issues. Since President Tsai Ing-wen has declared that the "Net-Zero Emissions by 2050" is the national goal of Taiwan, and the

goal of "Net-Zero Emissions by 2050" will be incorporated into the law. Net-zero emissions and climate change will be the key tasks of the NCSD in the future. For this reason, the "Climate Change and Carbon Reduction Task Force" will be renamed the "Climate Change and Net-Zero Emission Task Force," responsible for handling the tasks mentioned above. The CEO of NCSD directly supervises the Task Force. The organizational structure of the NCSD is shown in Figure 3.2.1-1:

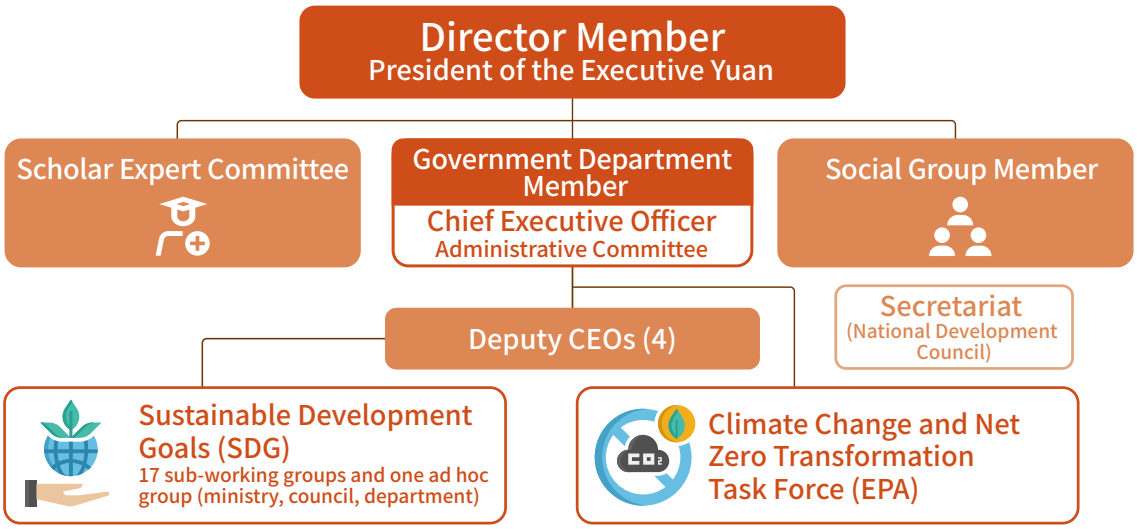

Figure 3.2.1-1: Organizational structure of the National Council for Sustainable Development

Source: Secretariat of the National Council for Sustainable Development

(3) Promotion progress

Since its establishment, the NCSD has proposed many important sustainable development strategies for Taiwan, including the "Agenda 21-Strategies for the Sustainable Development of the Republic of China," the "Sustainable Development Action Plan," the "Taiwan Sustainable Development Declaration," the "Taiwan Agenda 21-Vision and Strategies for National Sustainable Development," the "Strategies for Sustainable Development," the "Strategies and Directions for Promoting Green Economy" and the "Taiwan Sustainable Development Goals."

Regarding policy implementation, to promote Taiwan's sustainable development goals, the NCSD has set up the assessment for sustainable development indicator system and formulated the "Tracking and Evaluation Guidelines for Taiwan Sustainable Development Goals" in 2019. The major goals (including goal 7 affordable energy and goal 13 climate action related to climate change and carbon reduction) are tracked and evaluated, with the promotion results of the previous year reviewed yearly. Moreover, a periodic review is conducted every four years. In the future, the integration and coordination of various policies on mitigation, adaptation and net-zero emissions will also be strengthened to improve climate governance.

2. Office of Energy and Carbon Reduction

(1) Introduction

Taiwan established the "Council for Energy Saving and Carbon Reduction Promotion" in 2009. It was renamed the "Council for Renewable Energy and Low Carbon Promotion" in 2014. In response to the global trend of energy transformation and greenhouse gas reduction, the Executive Yuan established the "Office of Energy and Carbon Reduction" in 2016. It coordinates and plans national energy policies, promotes energy transformation and greenhouse gas reduction, and integrates inter-departmental related affairs. The main tasks of the Office of Energy and Carbon

Reduction include: the discussion and planning of national energy policy; the coordination and promotion of national energy and greenhouse gas reduction related laws and regulations; the review, tracking and evaluation of major energy and greenhouse gas reduction related plans; inter-departmental coordination and promotion of energy and greenhouse gas reduction related affairs; preparation of meetings for major energy and greenhouse gas reduction strategies; and regular reports on the progress of energy and greenhouse gas reduction policies to the premier.

(2) Organizational structure

The Office of Energy and Carbon Reduction has set up one convener and one co-convener, both of whom are from the Minister without Portfolio responsible for energy or science and technology related affairs and are appointed by the premier; three deputy conveners who are the Minister of MOEA (Ministry of Economic Affairs), the Minister of EPA (Environmental Protection Administration), and the Minister of MOST (Minister of Science and Technology); and 21~27 committee members. With the exception of the convener, co-convener and deputy convener as ex-officio members, the other members shall be assigned (appointed) by the Executive Yuan from the following personnel: (1) Deputy Minister of MOI (Ministry of Interior); (2) Deputy Minister of MOTC (Ministry of Transportation and Communications); (3) Deputy Minister of COA (Council of Agriculture); (4) Deputy Minister of NDC (National Development Council); (5) Deputy Minister of PCC (Public Construction Commission); (6) Deputy Minister of AEC (Atomic Energy Council); (7) President of TPC (Taiwan Power Company); (8) President of CSC (China Steel Corporation); (9) President of CPC (CPC Corporation, Taiwan); (10) CEO of Green Energy Industry Promotion Center; (11) CEO and Deputy CEO of the Office of Energy and Carbon Reduction; and (12) three to nine representatives of scholars, experts or non-governmental organizations. The organizational structure of the Office of Energy and Carbon.

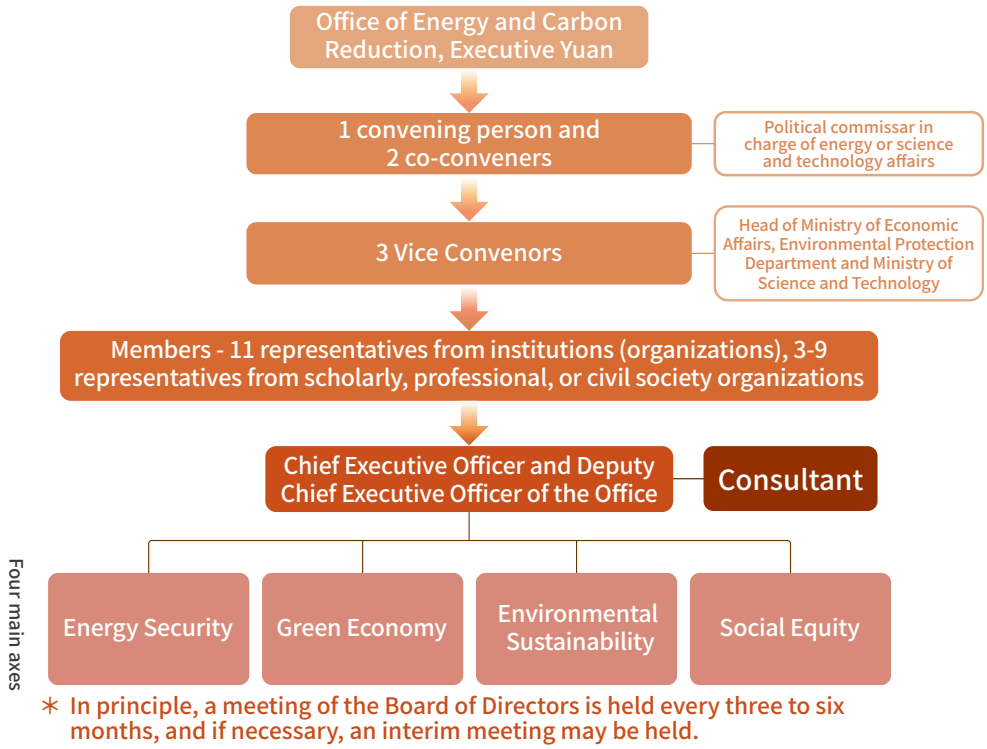

Figure 3.2.1-2: Organizational structure of the Office of Energy and Carbon Reduction

Source: Website of the Office of Energy and Carbon Reduction

(3) Promotion progress

The work focus of the Office of Energy and Carbon Reduction can be divided into six major areas, covering climate change, energy policy, renewable energy, smart grid, renewable energy technology, and environmental economy. In the promotion of bills, the Office of Energy and Carbon Reduction provided assistance in the amendment of the "Electricity Act," the "Renewable Energy Development Act," and the "Energy Administration Act." In terms of policy implementation, the Office of Energy and Carbon Reduction provided assistance in the promotion of the Energy Development Guidelines, the New Energy-Saving Initiative, the 4-Year Wind Power Promotion Project, the 2-Year Solar Photovoltaic Promotion Project, the Green Finance Action Plan, the 2020 Solar Photovoltaic 6.5-GW Compliance Project, the Smart Grid Master Plan, the Energy White Paper, the Forward-Looking Infrastructure Development Program: Green Energy, and the 5+2 Industrial Transformation Plan-Green Energy.

Recently, in response to the increasing efforts of global greenhouse gas reduction, the relevant ministries and departments of various sectors were invited to hold the "Second Greenhouse Gas Reduction Action Plan Discussion Workshop" in 2020, strengthening the content of the action programs for various sectors. Furthermore, the assessment of possible pathways for Taiwan's Net-Zero Emissions by 2050 was initiated in 2021. A "Vision Work Circle" was jointly organized by the Office of Energy and Carbon Reduction and the Environmental Protection Administration, inviting representatives from related private and government organizations. By strengthening the communication with

Greenhouse gas reduction and management method

Article 8 The central authorities to promote greenhouse gas reduction and climate change adaptation matters

On June 24, 105, the Executive Yuan convened the " Meeting on the Division of Work for Promoting Greenhouse Gas Reduction and Climate Change Adaptation" to establish the division of work among the ministries and agencies in charge of the promotion of Article 8 of the Climate Control Act and the central purpose of each department under Article 9.

	Promotional Items	Department	Organizer	Co-organizer
1	Renewable Energy and Energy Technology Development	Energy Department	Ministry of Economic Affairs	Ministry of Science and Technology
2	Energy Efficiency Improvement and Energy Saving		Ministry of Economic Affairs	Business Authorities by Purpose
3	Industrial sector greenhouse gas reduction	Manufacturing Divisiont	Ministry of Economic Affairs	Ministry of Science and Technology
4	Transportation management, mass transit system development and other transportation sector greenhouse gas reduction	Transportation Division	Ministry of Transportation and Communications	Ministry of Economic Affairs
5	Low carbon energy canister use		Ministry of Transportation and Communications	Ministry of Economic Affairs,Environmental Protection Department
6	Building greenhouse gas reduction management	Residential and Commercial Department	Ministry of the Interior	Ministry of Economic Affairs
7	Waste recycling and reuse	Environmental Sector	Environmental Protection Administration	Business Authorities by Purpose
8	Forest Resource Management, Biodiversity Conservation and Carbon Sequestration Enhancement	Agricultural Sector	Council of Agriculture	Ministry of the Interior
9	Agricultural greenhouse gas reduction management and food safety assurance		Council of Agriculture	-
10	Green Finance and Greenhouse Gas Reduction Incentive Mechanisms	Joint promotion between relevant departmentsn	National Development Council	Financial Supervisory Commission and Ministry of Finance
11	Greenhouse gas reduction on the overall economic impact assessment and response planning		National Development Council	Ministry of Economic Affairs
12	Establishment of greenhouse gas total control, offset, auction, allotment, trading system and promotion of international cooperative reduction mechanism		Environmental Protection Administration	Ministry of Economic Affairs, Financial Supervisory Commission and Ministry of Foreign Affairs
13	Research and development of greenhouse gas reduction technology and promotion		Ministry of Economic Affairs	Ministry of Science and Technology
14	Study of International Greenhouse Gas Convention Laws and Participation in International Conferences		Environmental Protection Administration	Business Authorities by Purpose
15	Development and promotion of climate change adaptation-related issues		National Development Council, Environmental Protection Administration	Business Authorities by Purpose
16	Education and promotion of climate change adaptation and greenhouse gas reduction		Environmental Protection Administration, Ministry Of Education	Business Authorities by Purpose
17	Other climate change adaptation and greenhouse gas reduction issues		Environmental Protection Administration	-

the private sectors, the planning of Taiwan's climate governance pathways for net-zero emissions that complies with sustainable development can be improved.

3. Division of work and operating mechanism of various ministries and departments based on the Greenhouse Gas Management Act

The competent authority of the Greenhouse Gas Management Act is the Environmental Protection Administration, which coordinates the national greenhouse gas reduction work. In terms of policy promotion, the Greenhouse Gas Management Act stipulates six major greenhouse gas emission sectors, including energy, manufacturing, transportation, residential and commercial, agricultural, and environmental sectors . The corresponding competent authority formulates the reduction strategies of each sector. In addition, Article 8 of the Greenhouse Gas Management Act lists 17 items relating to greenhouse gas reduction and climate change adaptation for promotion, which are promoted by the related agencies of the central government under the coordination of the Executive Yuan. The division of work of various ministries and departments is shown in Figure 3.2.1-3.

Greenhouse Gas Emission Control Action Plan (by department)	Centralized Purpose Business Authorities	Greenhouse Gas Emission Control Action Plan (by department)	Centralized Purpose Business Authorities
Energy Department	Ministry of Economic Affairs	Residential and Commercial Department	Ministry of the Interior and Ministry of Economic Affairs
Manufacturing Divisiont	Ministry of Economic Affairs and Ministry of Science and Technology	Environmental Sector	Ministry of Economic Affairs
Transportation Division	Ministry of Transportation and Communications	Agricultural Sector	Council of Agriculture

Figure 3.2.1-3: Division of work of various ministries and departments based on the Greenhouse Gas Management Act

Source: Website of national greenhouse gas reduction regulations

3.2.2 Introduction to laws and regulations related to greenhouse gas reduction

Taiwan's greenhouse gas reduction policies are based on the Greenhouse Gas Management Act. With the development of global trends, the Environmental Protection Administration is currently handling the amendment of laws based on the vision of net-zero emissions. In addition, there are other important energy-related laws and supporting policies in Taiwan, including the "Energy Administration Act," the "Electricity Act," and the "Renewable Energy Development Act" to accelerate the transformation to low-carbon energy.

1. Greenhouse Gas Reduction and Management Act

(1) Structure of the Greenhouse Gas Management Act

The Greenhouse Gas Management Act was announced and implemented on July 1, 2015. In accordance with the spirit of the United Nations Framework Convention on Climate Change, it assumes common but differentiated responsibilities, implements environmental justice, fulfills the responsibility of jointly protecting the global environment, and ensures the sustainable development of the nation. The Greenhouse Gas Management Act regulates Taiwan's long-term reduction goals, government agencies' authority and responsibilities, and greenhouse gas reduction countermeasures and education, serving as the bridge for integrating decision-making mechanisms and linking future international collaborations. It is divided into 6 Chapters with 34 Articles in total. Chapter 1: General Principles contains 7 Articles, Chapter 2: Authority and Responsibility of Government Agencies contains 8 Articles, Chapter 3: Emission Reduction Measures contains 8 Articles, Chapter 4: Education and Grants contains 4 Articles, Chapter 5: Penalty Provisions contains 5 Articles, and Chapter 6: Supplementary Provisions contains 2 Articles as shown in Figure 3.2.2-1.

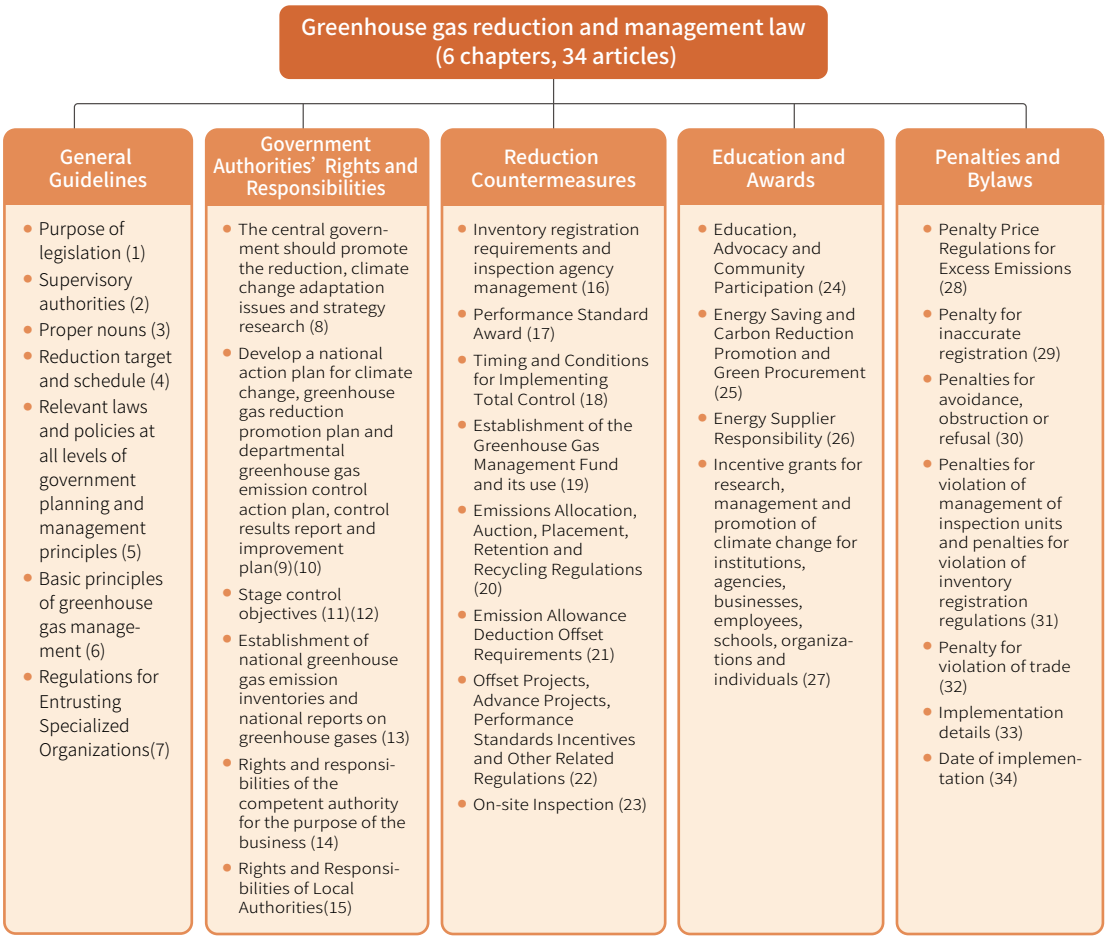

Figure 3.2.2-1: Structure of Greenhouse Gas Reduction and Management Act

Source: Website of national greenhouse gas reduction regulations

(2) Long-term reduction goals

Article 4 of the "Greenhouse Management Act" clearly stipulates that the national long-term reduction goals for 2050 for greenhouse gasses are to be 50% lower than Taiwan's greenhouse gas emission levels in 2005, and necessary adjustments may be made with reference to the conventions of the United Nations Framework Convention on Climate Change, its resolutions, or relevant international conventions and resolutions, as well as changes in domestic trends within the nation. Over 130 countries around the world have pledged or plan to meet Net Carbon Zero by 2050. Among them are the thirteen countries of Germany, Sweden, the United Kingdom, France, Spain, Denmark, Hungary, Luxembourg, Japan, Canada, New Zealand, South Korea, and Ireland, as well as the European Union, which has already enacted legislation for Net Zero Emissions or carbon neutrality goals. Both Chile and Fiji are currently in the process of passing such legislation. Taiwan's "Greenhouse Gas Management Act" focuses on greenhouse emissions reduction management and conforms to changes in global conditions. Taiwan's Environmental Protection Agency already announced on October 21, 2021, the amendments to the Environmental Protection Act and goals for Net Zero Emissions by 2050.

(3) Reduction measures

After the promulgation and implementation of the Greenhouse Gas Management Act, the central competent authority established an inventory registration system based on the Measurable, Reportable, and Verifiable (MRV) principles and supplemented by a greenhouse gas offset program to encourage businesses to carry out emission reduction as soon as possible. After the relevant mechanisms are

complete and under the premise of maintaining the competitiveness of Taiwan's industries, the situation of international climate negotiations will be taken into account to formulate and promote the cap and emission trading system, set the periodic total emission target, and implement the emission reduction measures gradually.

I. Implement an inventory registration system and establish a management baseline

In January 2016, the "Regulations for the Inventory and Registration of Greenhouse Gas Emissions" and the "First Batch of Emission Source that Requires Greenhouse Gas Emission Inventory and Registration" were announced. The targets that require greenhouse gas emission inventory and registration are mainly high energy-consuming industries, such as electricity, cement, steel, petroleum refining, optoelectronics, semiconductors, etc., and those whose annual greenhouse gas emissions of the entire plant (site) from the combustion of fossil fuels exceed 25,000 tons of CO_2e, including the paper industry, the artificial fiber industry, the printing, and dyeing industry, etc. The aforementioned targets are required to complete the greenhouse gas emission inventory and registration of the entire plant (site) for the previous year by the end of August each year.

Currently, there are about 285 to 290 businesses that require greenhouse gas emission inventory and registration. Taking 2019 as an example, 288 businesses were regulated and total direct emissions[1] registered were 224.63 million tons of CO_2e, of which about 80% of the emissions were from the combustion of fuels (181.27 million tons of CO_2e), suggesting that more than 84% of the emissions from fuel combustion in Taiwan's energy and industry sector can be grasped[2]. Based on the changes in emissions from 2015 to 2019 (Figure 3.2.2-2), it is apparent that the emissions have been declining year by year since 2017.

II. Establish an international greenhouse gas verification and management system

To ensure the quality of greenhouse gas inventory operation and data are reasonable, fair, and consistent, greenhouse gas verification agencies and management mechanisms have been established internationally. They are approved by government agencies

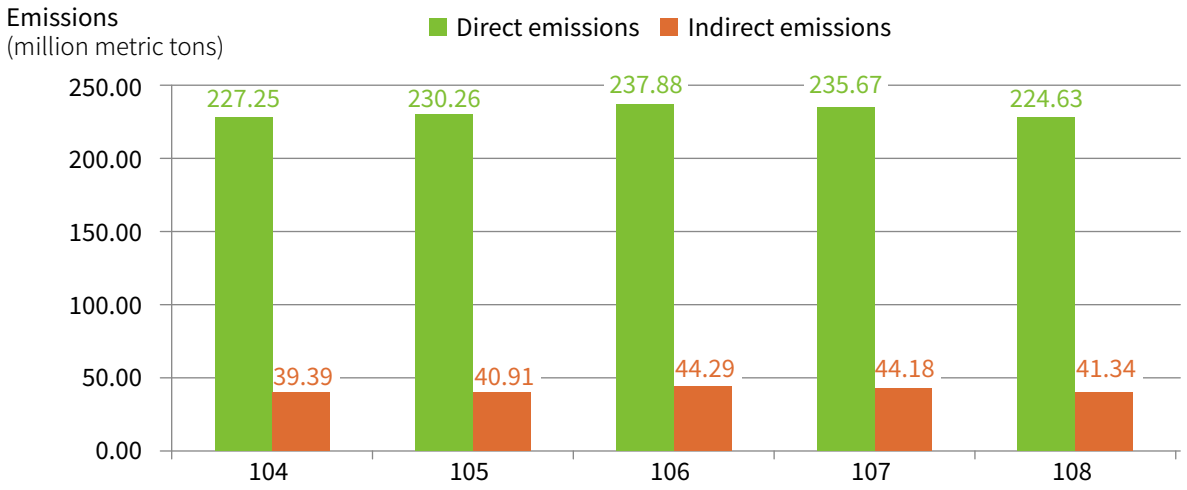

Figure 3.2.2-2: Targets that require greenhouse gas emission inventory and registration over the years

Source: Environmental Protection Administration, Executive Yuan

1. Emission types include fuel combustion, process emissions, mobile source emissions, and fugitive emissions

2. According to the statistics of the Bureau of Energy, the emissions from Taiwan's energy and industry sector in 2019 excluding electricity consumption statistics were 214.81 million tons of CO2e

or third-party verification bodies certified by international certification agencies for verifying greenhouse gas emissions and the effectiveness of emission reduction. Taking into account international experience, the Environmental Protection Administration has established the "Regulations for the Management of Greenhouse Gas Certification Agencies and Verification Bodies" as the legal basis for promoting greenhouse gas emission inventory and registration, ensuring the data quality of greenhouse gas emission inventory and registration in Taiwan. For the management of verification bodies, the certification systems commonly adopted and used internationally are considered. In addition, the certification agencies that are members of the International Accreditation Forum (International Accreditation Forum, IAF) are entrusted to complete the certification so as to ensure the consistency of the principles and specifications of the international management system. The certification process of verification bodies in Taiwan is shown in Figure 3.2.2-3. Currently, one certification agency has been entrusted, and seven verification bodies have been approved.

III. Encourage businesses to carry out emission reductions voluntarily

To encourage businesses to carry out greenhouse gas emission reduction as soon as possible, the Environmental Protection Administration referred to the practices of United Nations Clean Development Mechanism (CDM) and announced on September 10, 2010 the "Greenhouse Gas Early Action and Offset Program Promotion Principles," and established the "Regulations for the Management of Greenhouse Gas Offset Program" after the implementation of the "Greenhouse Gas Management Act," serving as an incentive to encourage businesses in carrying out emission reduction voluntarily and implementing emission reduction by means of renewable energy, energy efficiency improvement, or energy integration. Furthermore, emission reduction credits can be issued. The Environmental Protection Administration amended and announced the "Regulations for the Management of Greenhouse Gas Offset Program" on December 27, 2018, adding a new category of micro-scale offset program. In addition to reducing the verification costs, it also encourages

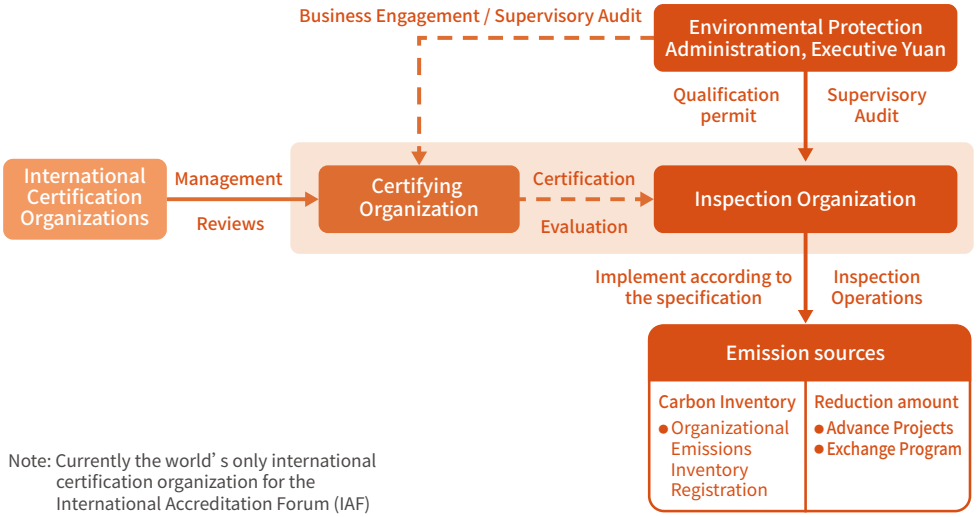

Figure 3.2.2-3: Certification process of verification bodies in Taiwan

Source: Environmental Protection Administration, Executive Yuan

private enterprises to collaborate with local governments in carrying out emission reduction.

According to statistics, as of October 2021, 85 greenhouse gas offset cases have been registered, which are mainly from the energy industry, the fugitive emissions of the manufacturing and use of halides and fluorosulfides, and the manufacturing industries (see Figure 3.2.2-4). It is estimated that the total emission reduction during the entry period will be 68,643,702 tons of CO_2e. Out of the 85 registered cases, 16 cases have obtained the emission reduction credit for the offset program, and 11,647,416 tons of CO_2e have been issued.

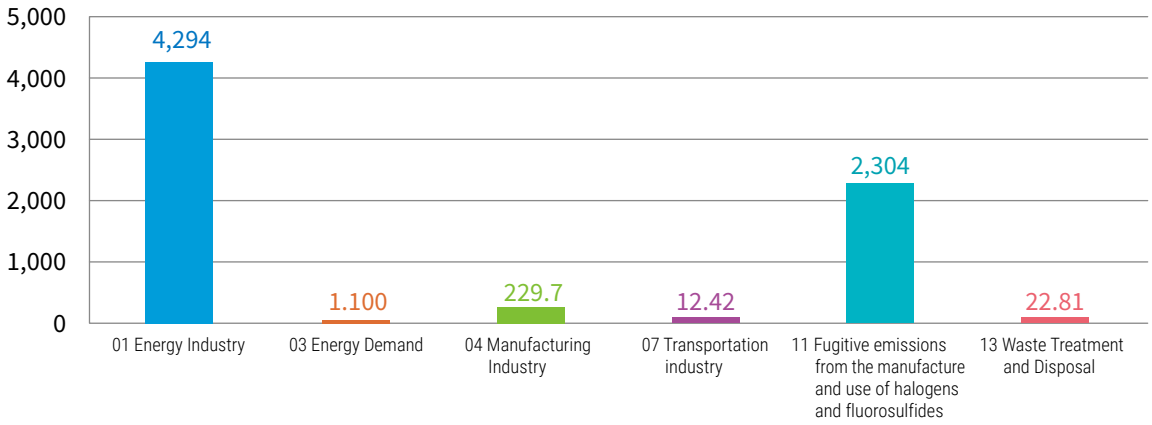

Figure 3.2.2-4: Amount of greenhouse gas offset by various sources

Source: Environmental Protection Administration, Executive Yuan

IIII. Amendment of the Greenhouse Gas Management Act

Since the announcement and implementation of the Greenhouse Gas Management Act on July 1, 2015, Taiwan has gradually established its greenhouse gas reduction system. Due to the severe global climate change situation and the continuous increase in the demand for carbon reduction in the industrial supply chain worldwide, countries around the world have reviewed their actions in response to climate change based on the framework of the Paris Agreement and actively carried out work relating to mitigation, adaptation, technology, funding, capacity building, and transparency, continuing to propose the goal of net-zero greenhouse gas emissions by 2050.

The current provisions of the Greenhouse Gas Management Act focus on greenhouse gas reduction management. To be in line with international standards, take into account the needs for sustainable development, adapt to the impact of global climate change, and build a resilience system, Taiwan must strengthen its adaptation actions, reduce the impact of climate change, incorporate international carbon pricing experience for levying carbon tax, and develop low-carbon technologies as well as incentive systems for the industries and the economy to achieve its goal of net-zero emission. For this reason, a draft amendment was proposed. The main content of the amendment includes: the inclusion of the net-zero emission by 2050 goal, increasing the level of management to strengthen climate governance, improving the implementation of reduction programs and plans, building adaptation capabilities and integrating scientific research, strengthening emission management, collecting carbon tax and using it for designated purposes,

promoting cooperation between the central and local governments and public-private collaboration, enhancing information transparency, and strengthening public participation mechanisms. The amendment was announced on October 21, 2021, and will be named the "Climate Change Response Act."

2. Energy-related laws and supporting policies

In addition to the Greenhouse Gas Management Act, Taiwan has also actively promoted energy-related laws and supporting policies, including the "Energy Administration Act," the "Electricity Act" and the "Renewable Energy Development Act." Long-term and short-term strategies are implemented to ensure a stable supply of electricity while expanding the development of renewable energy and requiring heavy electricity users to use renewable, gradually achieving electricity liberalization and promoting the development of the green industry in Taiwan.

(1) Energy Administration Act

To strengthen energy management and promote the rational and effective use of energy, the "Energy Administration Act" was promulgated and implemented in 1980, with the latest amendment in 2016. The "Energy Development Guidelines" was set by the Ministry of Economic Affairs as the upper-level guiding principle of the national energy policy. The "Energy Development Guidelines" amended on April 24, 2017, set four major goals for the energy policy of Taiwan, including "energy security," "green economy," "environmental sustainability," and "social justice." Through the expansion of renewable energy installations, the localization of the green energy industry, and the public's right to know, the decommissioning of nuclear power plants can be carried out as scheduled. In addition, electricity liberalization can be achieved to comprehensively promote energy transformation policies that cover energy saving, energy creation, energy storage, and smart system integration, gradually reducing the percentage of nuclear power generation to achieve the goal of a non-nuclear homeland by 2025.

(2) Electricity Act

To develop and effectively manage Taiwan's power resources and regulate the supply and demand of power, the "Electricity Act" was promulgated and implemented in 1947, and the latest amendment was in 2019. The "Electricity Act" was amended in 2017 based on the principle of green energy first. It will fully open up the power generation and direct supply, wheeling, and sale of green electricity such as solar and wind power, and establish a diversified energy supply and a market that is beneficial to the development of the green energy industry. It is expected to promote energy independence and environmental sustainability, protect household users, and develop innovative industries. In addition, control of electricity carbon emission factor will be implemented for Electricity Retailing Utility Enterprise to encourage cooperation between Electricity Retailing Utility Enterprise and Renewable-Energy-Based Electricity Generating Enterprise, creating a low-carbon electricity market. After the supporting management and the legal systems have been operated smoothly, and the market has been well developed, the second-phase amendment of the Act will be conducted to open up the direct supply and wheeling of other traditional energy to regular Electricity Retailing Enterprise, gradually promoting the reform of Electricity Enterprise.

(3) Renewable Energy Development Act

To achieve the goal of 20% in Taiwan's renewable energy generation by 2025, the "Renewable Energy Development Act " was promulgated and implemented in 2009, with the latest amendment in 2019. This amendment specifies an installed capacity target of 27 GW for renewable energy in Taiwan by 2025 and sets a short-term promotion target every two years. Electricity Enterprise can freely change renewable energy certificate (REC) and wholesale purchasing systems. Governmental agencies and heavy electricity users must install renewable energy or energy storage equipment with a certain capacity (those who are unable to make the installation shall purchase green electricity or pay monetary substitution instead). In terms

of technology, the R&D or subsidy for energy storage and renewable energy resource inventory is increased. In addition, the Act emphasizes citizen participation in energy affairs, listing the Green Advocates - Energy Cooperative and citizen power plants as the targets for subsidies, and increasing subsidies for areas of indigenous people.

3.3 Greenhouse gas reduction policies and measures

The Greenhouse Gas Management Act establishes a hierarchical promotion structure for the central government, ministries/departments, and local governments. The Environmental Protection Administration will discuss with the Bureau of Energy (BOE, MOEA), the Industrial Development Bureau (IDB, MOEA), the Ministry of Transportation and Communications, the Ministry of the Interior, and the Council of Agriculture to develop a national-level "Climate Change Action Guideline" and "Greenhouse Gas Reduction Action Plan," which are then submitted to the Executive Yuan for approval, formulating the principles and policies for Taiwan's greenhouse gas reduction. The implementation of the action programs needs to be further carried out through the "Greenhouse Gas Emission Control Action Plan" of the six major sectors, including energy, manufacturing, transportation, residential and commercial , agricultural and environmental sector, as well as the "Greenhouse Gas Control Implementation Plan" formulated by local governments based on regional characteristics to propose specific reduction policies and measures.

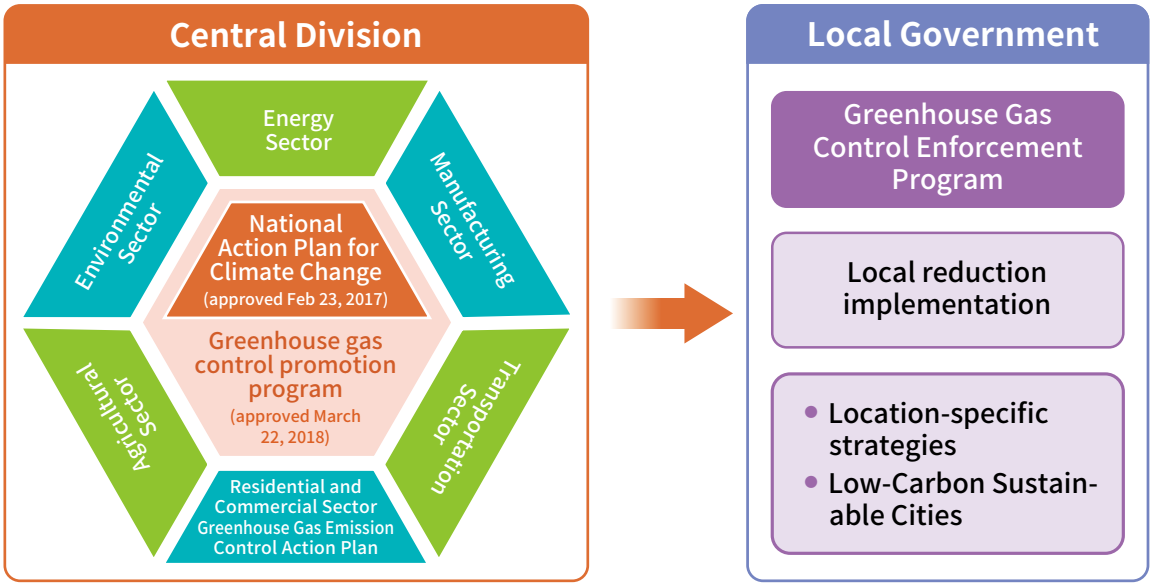

Figure 3.3-1 Hierarchical promotion structure for the central and local governments regulated by the Greenhouse Gas Management Act

Source: Website of national greenhouse gas reduction regulations

3.3.1 National Climate Change Action Guideline

1. Framework of the Action Guideline

The Environmental Protection Administration, Executive Yuan formulated the "National Climate Change Action Guideline" (hereinafter referred to as the "Action Guideline") in accordance with Paragraph 1, Article 9 of the Greenhouse Gas Management Act, which was approved by the Executive Yuan on February 23, 2017, serving as the principles for promoting Taiwan's greenhouses gas mitigation and climate change adaptation policies. The Action Guideline takes into account the Paris Agreement and the United Nations Sustainable Development Goals for 2030. It upholds the spirit of taking both mitigation and adaptation into consideration and sets out ten basic principles for Taiwan to respond to climate change. The policy includes six major sectors of greenhouse gas reduction, eight major areas

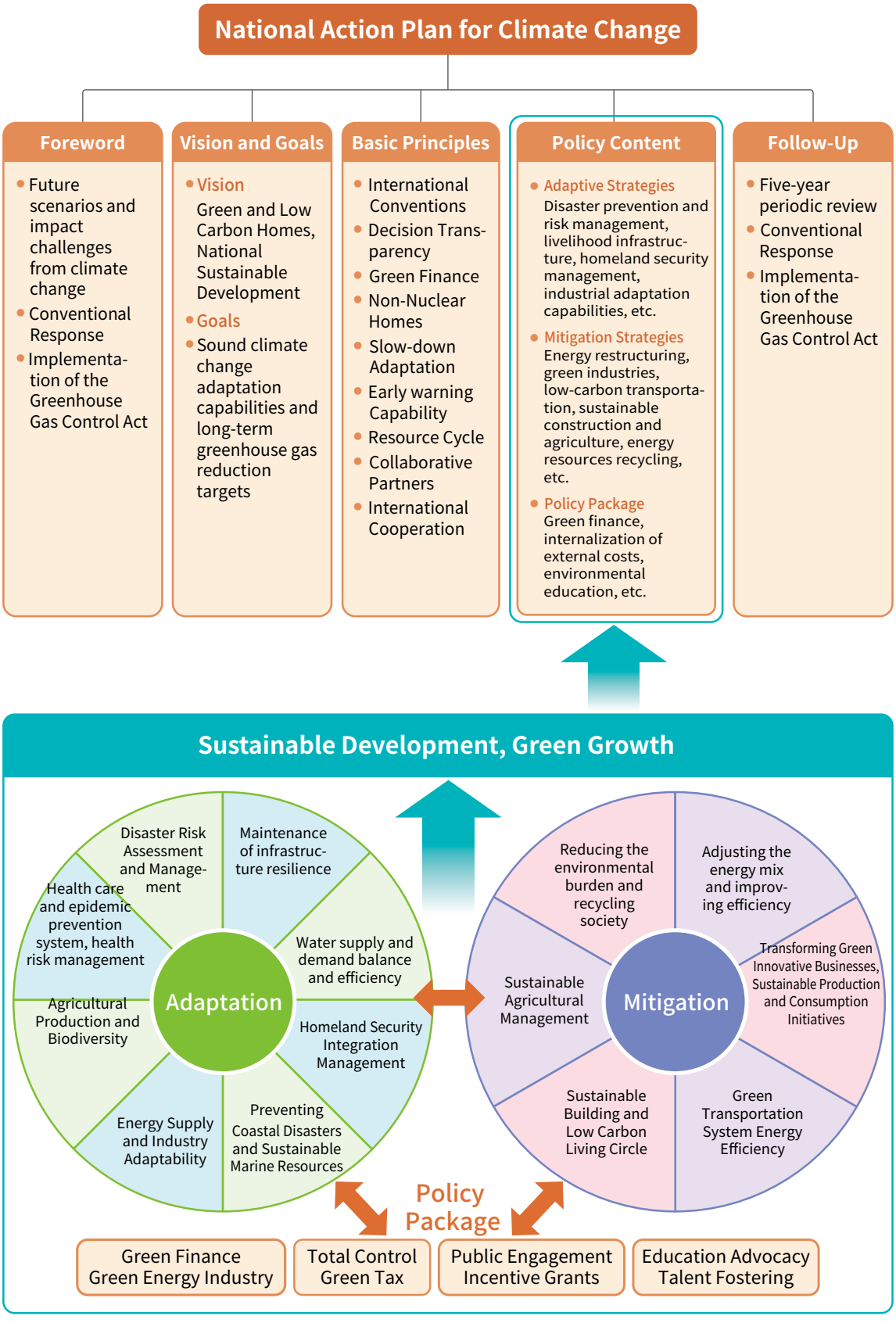

Figure 3.3.1-1 : Framework of the National Climate Change Action Guideline

Source: Website of national greenhouse gas reduction regulations

of climate change adaptation, and supporting measures. It also launched cross-departmental response actions, hoping to gradually improve Taiwan's capability in coping with climate change and striving to achieve Taiwan's long-term greenhouse gas reduction goals to ensure sustainable development of the nation. The framework of the Action Guideline and content of the policy is shown in Figure 3.3.1-1.

2. Vision and goals

The Action Guideline used Taiwan's long-term vision and goals in response to climate change specified by the Greenhouse Gas Management Act as the basis to formulate climate change adaptation strategies for reducing and managing greenhouse gas emissions in order to build a green and low-carbon home that can adapt to climate risks, ensuring sustainable development of the nation.

3. Establish basic principles

The Action Guidelines establish the policy direction of Taiwan in response to climate change, covering ten basic principles, including

Table 3.3.1-1: Basic principles of the "National Climate Change Action Guideline"

Aspect	Basic principle
International conventions	Follow the "Paris Agreement" to promote the mitigation of greenhouse gas emissions. Stop and reduce the use of hydrofluorocarbons, the greenhouse gas with high global warming potential, in accordance with the Kigali Agreement of the "Montreal Protocol."
Transparency in decision-making	Open and transparent in decision making and implementation, and consider the common benefits of various environmental issues. Promote greenhouse gas reduction and climate change adaptation strategies under the spirit of the lowest cost.
Green finance	Promote green finance and carbon pricing mechanisms. Strengthen or increase economic incentive mechanisms through greenhouse gas cap and emission trading systems as well as related taxing systems to promote greenhouse gas reduction, assist the development of green industries, enhance national competitiveness, and improve social welfare.
Non-nuclear homeland	According to the goal of a non-nuclear homeland, the addition of new nuclear power generation should not be used as a response measure to climate change.
Mitigation and adaptation	Government policies and individual development plans should consider climate change adaptation and mitigation strategies while carrying out environmental impact assessment.
Early warning capabilities	Strengthen scientific foundation, develop comprehensive early warning capability, improve the adaptation actions in response to climate change, and build resilient development.
Resource recycling	Improve the efficiency of resource and energy use, promote the recycling of resources, and ensure national energy security and sustainable use of resources.
Cooperative partners	Establish a partnership between the central and local governments, collaborative relationships between public and private sectors, and communication platforms to specifically promote localized adaptation and mitigation work.
International cooperation	Promote international cooperation and exchanges, uphold the principle of mutual benefit, promote meaningful participation and substantive contributions, and maintain the international competitiveness of industrial development.
Public participation	Enhance the awareness and skills of the public on climate change and actively assist non-governmental organizations in promoting related activities and matters.

Source: "National Climate Change Action Guideline," 2017, Environmental Protection Administration, Executive Yuan

international conventions, transparency in decision-making, green finance, non-nuclear homeland, mitigation and adaptation, early warning capabilities, resource recycling, cooperative partners, international cooperation, and public participation, as shown in Table 3.3.1-1.

3.3.2 National Greenhouse Gas Reduction Action Plan

1. Framework of the Action Plan

The Environmental Protection Administration, Executive Yuan formulated the "Greenhouse Gas Reduction Action Plan" (hereinafter referred to as the "Action Plan") in accordance with Paragraph 1, Article 9 of the Greenhouse Gas Management Act, which was approved by the Executive Yuan on March 22, 2018. The Action Plan sets up the division of authority and responsibilities, policy guidelines, and the evaluation indicators of implementation effectiveness for cross-departmental reduction strategies (eight major cross-departmental supporting measures including cap, environmental tax system, green finance, green energy industry, impact analysis, and technology R&D, information diffusion and subsidies, climate talent cultivation and awareness enhancement, regulation review and amendment, and sound mitigation finance mechanisms) and the reduction policies of the six major sectors (including the energy sector, manufacturing, transportation, residential and commercial, agricultural and environmental sectors), hoping to integrate the capacities of various ministries and departments to jointly carry out the carbon reduction work. In addition, a rolling review mechanism is adopted every five years, serving as a strengthening measure to help achieve the carbon reduction target year by year. The framework of the Action Plan is shown in Figure 3.3.2-1

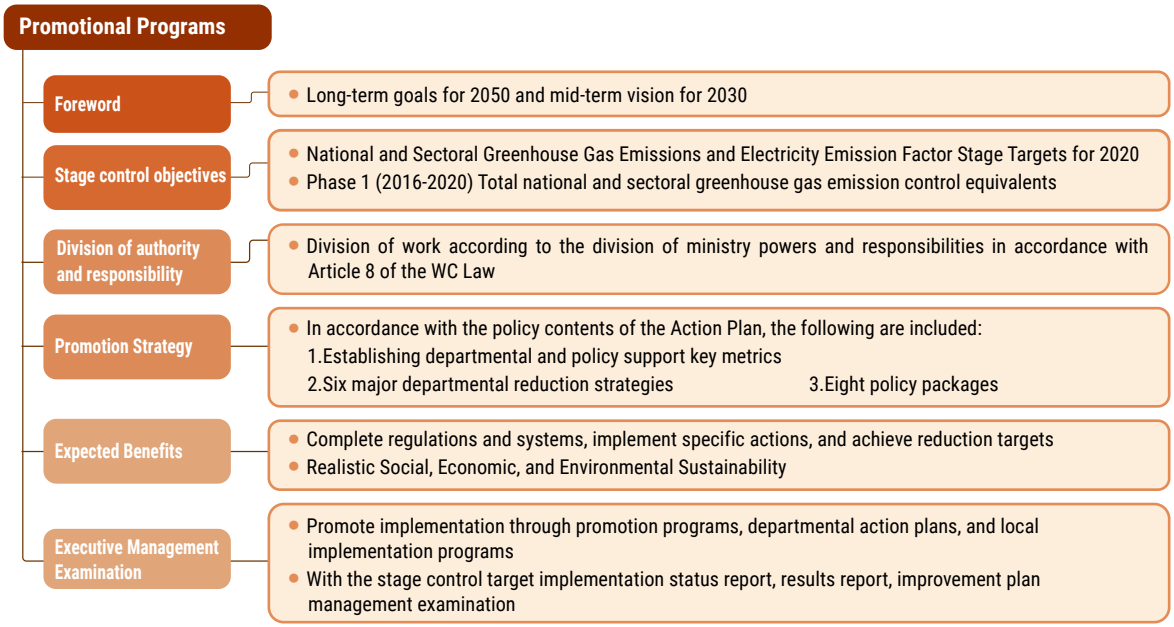

Figure 3.3.2-1 : Framework of the Greenhouse Gas Reduction Action Plan

Source: "Greenhouse Gas Reduction Action Plan", 2018, Environmental Protection Administration, Executive Yuan

2. Vision and goals

Based on Taiwan's short, medium and long-term greenhouse gas reduction goals, the Action Plan formulates national and cross-departmental response strategies, establishes operating mechanisms for central and local governments, public and private partners, and public participation, and implements the national greenhouse gas reduction policy.

To achieve the long-term reduction goal of reducing greenhouse gas emissions by 2050 to less than 50% of the greenhouse gas emissions in 2005, as specified in Article 4 of the Greenhouse

Gas Management Act, Taiwan has set periodic short- and medium-term targets every five years. The implementation period for the phase I greenhouse gas regulatory goal is from 2016 to 2020. The Executive Yuan ratified the Phase II greenhouse gas regulatory goals on September 29, 2021, and incorporated them into the 2050 Net Zero Emissions long-term reduction goals, as well as the pragmatic review of mid-range carbon reduction path planning. The Environmental Protection Agency has already formally requested that relevant sectors make amendments to their rules and regulations, and on November 2, 2021, drafted the bill for the "Phase II Greenhouse Gas Reduction Promotion Act," including a report to the Executive Yuan. Taiwan's short, medium, and long-term greenhouse reductions are shown in Figure 3.3.2-2. The reduction goals of various sectors are as shown in Figure 3.3.2-1:

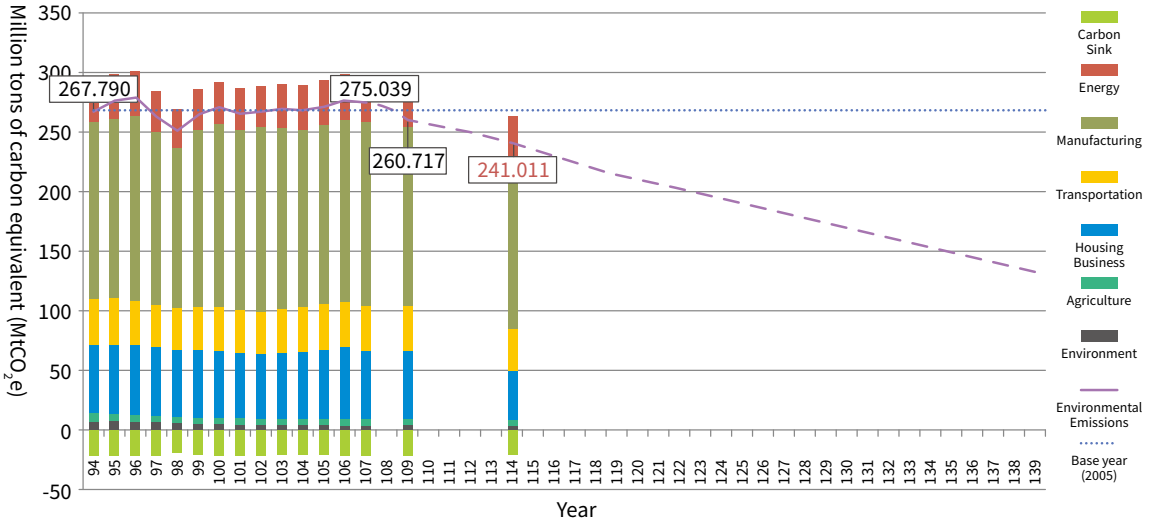

Figure 3.3.2-2: Taiwan's greenhouse gas reduction roadmap

Source: Environmental Protection Administration, Executive Yuan

Table 3.3.2-1: National and sector-specific greenhouse gas regulatory goals

		2020 greenhouse gas emissions target values	Phase I regulatory goals (The total equivalent of greenhouse gas emission regulated from 2016 to 2020)	2025 greenhouse gas emissions target values	Phase II Regulatory goals (The total equivalent of greenhouse gas emissions regulated from 2021 to 2025)
National		260.717 $MtCO_2e$	1437.531 $MtCO_2e$	241.011 $MtCO_2e$	1,400.284 $MtCO_2e$
Six major sectors	Energy	32.305 $MtCO_2e$	163.239 $MtCO_2e$	34.000 $MtCO_2e$	182.504 $MtCO_2e$
	Manufacturing	146.544 $MtCO_2e$	741.543 $MtCO_2e$	144.000 $MtCO_2e$	753.454 $MtCO_2e$
	Transportation	37.211 $MtCO_2e$	189.663 $MtCO_2e$	35.410 $MtCO_2e$	181.626 $MtCO_2e$
	Residential and commercial	57.530 $MtCO_2e$	298.845 $MtCO_2e$	41.421 $MtCO_2e$	241.331 $MtCO_2e$
	Agricultural	5.318 $MtCO_2e$	26.187 $MtCO_2e$	5.006 $MtCO_2e$	27.814 $MtCO_2e$
	Environment	3.496 $MtCO_2e$	18.154 $MtCO_2e$	2.564 $MtCO_2e$	13.555 $MtCO_2e$
Electricity carbon emission factor		0.492 kg CO_2e/kWh[Note] (2020 target)	0.517 kg CO_2e/kWh (annual average)	0.388 kg CO_2e/kWh[Note] (2020 target)	0.447 kg CO_2e/kWh (annual average)

Source: "Greenhouse Gas Reduction Action Plan," 2018, Environmental Protection Administration, Executive Yuan

Note: Excluding the amount of electricity and emissions for power plants, self-use power generation equipment, plant use, and line loss

(1) Phase I (2016-2020) Target: a reduction of 2% from the base year (2005) by 2020

(2) Phase II (2021-2025) Target: a reduction of 10% from the base year (2005) by 2025

(3) Phase III (2026-2030) Target Vision: maintain the goal of 20% reduction by 2030 with a rolling review being adopted

Energy Department	• Phased reduction of electricity emission factor stage targets • Avoiding inappropriate subsidies for fossil fuels in order to gradually internalize Ministry of the Environment costs
Manufacturing Division	• Promoting low-carbon fuel substitution in the industrial sector and promote the switch to clean fuels • Promoting enterprises to establish management mechanisms and organizational rights and responsibilities in response to climate change
Transportation Division	• Strengthening the public transportation system and establish an incentive mechanism for transferring private transport to the public transportation system • Continuing to tighten vehicle energy consumption standards, targeting manufacturers or importers to improve average fuel consumption
Residential and Commercial Department	• Reviewing amendments to building-related codes to increase building envelope energy efficiency design benchmark values • Completing the building energy efficiency assessment tool, planning to promote the building energy passport
Agriculture Department	• Promoting a friendly agricultural, forestry, fishery and livestock production environment, and enhancing agricultural energy and resource recycling • Actively promoting afforestation and reforestation to enhance carbon sinks and carbon sequestration benefits
Environment Department	• Establishing a circular production and lifestyle, promoting recycling and reuse of factory waste • Promoting material recovery technology, recovering precious metals in Taiwan, and moving towards a circular economy

Figure 3.3.2-3 : Strategies for six major sectors based on the "Climate Change Action Guideline"

Source: "Greenhouse Gas Reduction Action Plan," 2018, Environmental Protection Administration, Executive Yuan

3.Reduction strategies for six major sectors

The Action Plan follows the principles of greenhouse gas mitigation planned by the "National Climate Change Action Guideline" and develops strategies for six major sectors. The strategies and evaluation items of various sectors are shown in Figure 3.3.2-3:4.

4. Cross-departmental supporting measures

The implementation of greenhouse gas reduction needs to be supported by sound laws and regulations, economic incentives, and education. The priority is to review regulations and remove system obstacles. By formulating or revising relevant regulations, incentives and

Promoting total greenhouse gas control	Obtaining baseline information on emission sources and establishing a total control and emission trading system
Promoting a green tax system	Studying the feasibility of introducing energy or carbon taxes, and establishing a competitive evaluation and integration mechanism with related taxes and fees
Green Finance and Green Energy Industry Development	Promoting green financing and green bonds, activating the use of private capital to lead the development of green energy industries, and promoting the construction of low-emission firmware
In response to the economic impact of temperature reduction and the reduction of technological research and development	Evaluating the impact of GHG reduction on the overall economy and promoting R&D in GHG reduction technologies
Building information pipeline and providing incentive grants	Establishing easy access to information on climate change for the public and providing incentives or subsidies to promote behavior change for all
Fostering Talent and Raising Awareness and Action for All	Promoting environmental education on climate change, foster talents to respond to climate change, and enhancing the awareness, skills and mobility of all people
Review of amendments to regulations related to greenhouse gas reduction	Reviewing the barriers to the promotion system and taking stock of the control and reward mechanisms related to temperature reduction to integrate and expand the promotion efforts
Sound financial mechanisms for climate change mitigation	Providing an overview of the sources, uses, and amounts of funds to promote climate change mitigation

Figure 3.3.2-4: Eight major supporting measures based on the "Climate Change Action Guideline"

Source: "Greenhouse Gas Reduction Action Plan," 2018, Environmental Protection Administration, Executive Yuan

mechanisms, and checking the sources, usage and amount of relevant funds, appropriate incentives and environment for greenhouse gas reduction can be created to ensure successful implementation of the reduction work. The supporting measures and key indicators are shown in Figure 3.3.2-4.

3.3.3 Sector-specific Greenhouse Gas Emission Control Action Programs

In order to achieve the periodic regulatory goal for greenhouse gas emission reduction, the responsible ministries and departments of the six major sectors, including the energy, manufacturing, transportation, residential and commercial, environmental, and agricultural sector, will formulate the sector-specific "Greenhouse Gas Emission Control Action Programs" separately. Based on industry adjustments as well as energy supply and demand, the Action Programs mentioned previously will be reviewed and revised on a regular basis. A report on the results of the implementation of emission control should be prepared every year. Those who fail to achieve the emission control goal should propose an improvement plan. The following describes the implementation results of the important greenhouse gas reduction strategies of Phase I "Greenhouse Gas Emission Control Action Programs" for each sector (2016-2020):

1.Energy sector

Governed by the Ministry of Economic Affairs, the Action Programs for the energy sector includes 13 strategies and 42 plans. The key tasks include constructing a low-carbon energy supply system and promoting energy transformation to increase the percentage of renewable energy generation to 20% by 2025, greatly increase the installation

Table 3.3.3-1: Progress of implementing the assessment indicators for the energy sector

Assessment indicator	2020 Goal	2020 Progress	Progress percentage (%)
Electricity carbon emission factor	0.492 kg CO2e/kWh	0.502 kg CO2e/kWh	-
IInstalled capacity for renewable energy power generation	10,875MW	9,482 MW	87.19%
Renewable energy power generation	25,200 GWh	15,300 GWh	60.71%
NNatural gas unloading capacity	16.50 million tons per year	16.50 million tons per year	100%
Increase natural gas power generation	Carbon reduction of 1,672,100 tons of CO2e	Carbon reduction of 1,703,100 tons of CO2e	101.85%
Improve the efficiency of existing thermal power generating units	Carbon reduction of 30,300 tons of CO2e	Carbon reduction of 30,300 tons of CO2e	100%
Refinery energy efficiency improvement project	Carbon reduction of 105,500 tons of CO2e	Carbon reduction of 113,200 tons of CO2e	107.30%

Source: Greenhouse Gas Emission Control Action Programs (Phase 1) Approved Version for the energy sector, and 2020 Greenhouse Gas Emission Control Implementation Report for the energy secto

of renewable energy, including solar photovoltaic and wind power generation, improving LNG unloading capacity to increase the percentage of natural gas power generation to 50% by 2025, and gradually reducing the use of coal as well as the percentage of coal-fired power generation to less than 30% by 2025. The progress of implementing the assessment indicators and other quantitative indicators for the energy sector is summarized as shown in Table 3.3.3-1

2. Manufacturing sector

Governed by the Ministry of Economic Affairs, the Action Programs for the manufacturing sector includes 13 strategies and 30 measures. They are implemented through strengthening the guidance of carbon reduction in the industries and promoting industrial transformation as well as sustainable production processes. The key tasks include promoting the integration of regional energy resources, guiding the industry to integrate

Table 3.3.3-2: Progress of implementing the assessment indicators for the manufacturing sector

Assessment indicator	2020 Goal	2020 Progress	Progress percentage (%)
Decline in carbon intensity	43%	45.7% (2019 data)	106.28%
Promote process improvement and equipment replacement in the industrial sector	Provide on-site guidance to a total of at least 500 factories	Completed for 434 factories	86.80%
Promote low-carbon fuel replacement in the industrial sector	Provide on-site guidance to a total of at least 100 factories	Completed for 95 factories	95%
Promote regional energy/resource integration_factory guidance	1. Conduct energy/resource integration consultations for at least 15 factories every year Conduct consultation diagnosis or hold integration discussion meetings. 2. Add a total of 15 factories	Completed for 136 factories	181.33%
Promote change of fuel for industrial boilers and improve air pollution	Provide guidance to a total of at least 650 factories	Completed for 1,220 factories	187.69%
Provide system optimization services	Provide guidance to a total of 800 factories	Completed for 1,045 factories	130.63%
ISO/CNS50001 Energy Management System and Energy-saving Diagnosis integrated guidance_assist factory to import the system	Help 48 factories to import energy management system applications	Completed for 79 factories	164.58%
Provide talent training courses_ course management	Organize a total of 45 sessions of training courses or seminars	A total of 73 sessions of training courses or seminars were held	162.22%
Provide talent training courses_ Number of attendances	A total attendance of 1,500 is reached for all training courses	A total attendance of 2,316 is reached	154.40%

Assessment indicator	2020 Goal	2020 Progress	Progress percentage (%)
Promote the introduction of green design for the development of products	Provide guidance to a total of 15 companies	Completed for a total of 16 companies	106.67%
Promote guidance to green supply chain system	Provide guidance to a total of 32 companies	Completed for a total of 56 companies	175.00%
Promote the green factory label system	Accept applications from a total of 80 companies	Applications were received from 82 companies	102.50%

Source: 2020 Greenhouse Gas Emission Control Implementation Report for the manufacturing sector

energy resources and waste recycling, establishing an ecological industrial system, achieving a balance between regional energy supply and demand, and improving the overall energy/resource utilization efficiency. The progress of implementing the assessment indicators and other quantitative indicators for the manufacturing sector is summarized as shown in Table 3.3.3-2:3.

Transportation sector

3. Transportation sector

Governed by the Ministry of Transportation and Communications, the Action Programs for the transport sector have three major strategies and 11 specific measures or projects. The three major strategies include "Developing a public transportation system and strengthening transportation demand management"; "Constructing a green transportation network, promoting the use of low-carbon vehicles, and building a green transportation-oriented transportation environment"; and "Improving the energy utilization efficiency of transportation systems and equipment." The aim is to continuously increase the volume of public

Table 3.3.3-3: Progress of implementing the assessment indicators for the transportation sector

Assessment indicator	2020 Goal	2020 Progress	Progress percentage (%)
Passenger capacity of highway public transport	2% increase from 2015	Declined by 11.39% (Affected by the COVID-19 pandemic)	-
Passenger capacity of TRA	2% increase from 2015	Declined by 12.36% (Affected by the COVID-19 pandemic)	-
Passenger capacity of THSR	24.6% increase from 2015	Declined by 13.21% (Affected by the COVID-19 pandemic)	53.70%
Passenger capacity of MRT	16.1% increase from 2015	Declined by 1.18% (Affected by the COVID-19 pandemic)	89.19%
National electric scooter sales volume	Increase the sale of 121,000 electric scooters from 2018 to 2020	The sale of electric scooters increased by 350,000	289.26%
Replacing scooters with two-stroke engine	Replacing 1,050,000 scooters with two-stroke engine	468,000 scooters with two-stroke engine were replaced	44.6%

Assessment indicator	2020 Goal	2020 Progress	Progress percentage (%)
Replacing large phases 1 and 2 diesel vehicles	Replace a total of 79,000 vehicles by 2022	A total of 43,581 vehicles were replaced	55.17%
Replacing old TRA vehicles_ inter-city bus	Plan to purchase 600 inter-city buses	600 inter-city buses were purchased	100%
Replacing old TRA vehicles_ shuttle bus	Plan to purchase 520 shuttle buses	520 shuttle buses were purchased	100%
Replacing old TRA vehicles_ scooter	Plan to purchase 127 scooters	102 scooters were purchased	80.31%
Replacing old TRA vehicles_ branch line coach	Plan to purchase 60 branch line coaches	60 branch line coaches were purchased	-
Replacing electric postal vehicles_2-wheel electric scooter	From 2017 to 2023, replace 7,000 2-wheel electric scooters, and the target for 2020 based on the projection will be 3,000	2,441 2-wheel electric scooters have been purchased or rented	81.36%
Replacing electric postal vehicles_3-wheel electric scooter	From 2017 to 2023, replace 1,946 3-wheel electric scooters, and the target for 2020 based on the projection will be 834	None (Currently, there is no related products on the market)	0%
Replacing electric postal vehicles_4-wheel electric car	From 2017 to 2023, replace 2,200 4-wheel electric cars, and the target for 2020 based on the projection will be 843	54 4-wheel electric cars have been replaced (There is not enough 4-wheel electric cars appropriate for postal services on the market)	5.73%
Replacing the diesel-powered boats in the Sun Moon Lake with electric boats	From 2012 to 2017, replace 138 diesel-powered boats in the Sun Moon Lake with electric boats	11 diesel-powered boats were replaced	7.97%
Improving the energy efficiency of new cars	According to the announcement in 2018, the overall new vehicle fuel consumption control targets for passenger cars, commercial vehicles and scooters in 2022 are 20, 13.7 and 46.1 km/L, respectively, an increase of 38%, 25% and 10% from 2017	The overall new vehicle energy efficiency in 2020 for passenger cars, commercial vehicles and scooters reached 15.6, 12.75 and 47.62 km/L, respectively	100%
Promoting electric vehicle for fruit and vegetable transportation	Add 300 electric vehicles for fruit and vegetable transportation	50 electric vehicles for fruit and vegetable transportation were added	16.67%
Replacing old buses that do not meet the phase 4 requirements	Replace 1,200 old buses that do not meet the phase 4 requirements	1,260 old buses were replaced	105%

Source: 2020 Greenhouse Gas Emission Control Implementation Report for the transportation sector, and the information provided by the Ministry of Transportation and Communications and the Bureau of Energy (Ministry of Economic Affairs)

transportation (i.e., increase at least 7% by 2020 compared to 2015), slow down and reduce the use of private vehicles, and cooperate with the Executive Yuan's announcement of the vehicle electrification policy. It is expected that municipal buses will be fully electric in 2030. The progress of implementing the assessment indicators and other quantitative indicators for the transportation sector is summarized as shown in Table 3.3.3-3:4.

4. Residential and commercial sector

The Action Programs for the residential and commercial sector is governed by the Ministry of the Interior (where the Ministry of Economic Affairs is responsible for the commercial sector and the Ministry of the Interior is responsible for the residential sector), with a total of 37 specific measures or plans. The focus of the phase I control for the residential and commercial sector is to enhance the energy-saving design benchmark value for the envelope of newly-constructed buildings, to strengthen the reduction management of existing buildings, and to plan to build the carbon reduction capability of the competent authorities in the service sector. Strategies and measures at this stage include the

Table 3.3.3-4: Progress of implementing the assessment indicators for the transportation sector

Assessment indicator	2020 Goal	2020 Progress	Progress percentage (%)
Energy-saving design benchmark value for the envelope of newly-constructed buildings	10% increase of the value from 2016	On August 19, 2019, part of the building design and construction provisions of the "Building Technical Regulations" was revised. On December 4, 2019, the "Technical Code for Energy Conservation Design of Buildings" was established and implemented since 2021, which is expected to increase the value by 5%.	50%
Completing and implementing a transparent mechanism for the energy consumption of building envelope	Complete and implement a transparent mechanism for the energy consumption of building envelope	Consider that building envelope does not directly consume energy, the energy efficiency label of our building is currently being promoted. On January 12, 2021, the green building label was revised and applied for review and approval. In addition, operation guideline was used to strengthen energy efficiency and driving buildings to voluntarily label building energy efficiency ratings.	100%
Postal and transportation services implement energy-saving management measures	Reduction of 14,400 tons of CO_2	48,909 tons of CO_2e	339.65%
Promoting energy saving and carbon reduction in tourist hotel and hotel industry	Reduction of 600 tons of CO_2	758 tons of CO_2e	126.33%
Replacing tunnel lighting fixtures	Reduction of 1300 tons of CO_2	1493 tons of CO_2e	114.85%
Implementing energy-saving design control for new buildings_random inspection	Conduct approximately 4,000 random inspections of construction license for green buildings every year	An average of 4,131 random inspections were conducted per year	103.28%
Implementing energy-saving design control for new buildings_ propaganda	Conduct 30 sessions of green building propaganda every year	An average of 34 sessions of green building propaganda were conducted per year	113.33%

Assessment indicator	2020 Goal	2020 Progress	Progress percentage (%)
1% power saving requirement for exhibition venues	Meet the 1% power saving requirement for Taipei World Trade Center, Taipei International Convention Center, Taipei Nangang Exhibition Center Hall 1, Kaohsiung Exhibition Center	Complied with the requirement	100%
1% power saving requirement for exhibition venues	Meet the 1% power saving requirement for Taipei World Trade Center, Taipei International Convention Center, Taipei Nangang Exhibition Center Hall 1, Kaohsiung Exhibition Center	Complied with the requirement	100%
Saving electricity via autonomous target management for the financial industry	Reduction of 32,100 tons of CO_2	Reduced 67,400 tons of CO_2e	209.96%
Promoting energy saving and carbon reduction goals for hospitals_declaration	The estimated reduction is 63,300 tons of CO2	116,800 tons	184.52%
Energy-saving guidance for chain enterprises	Reduction of 22,200 tons of CO_2	38,000 tons of CO_2e	171.17%
Guidance on greenhouse gas reduction demonstration for the commercial service industry	Assist 40 companies in reducing greenhouse gas emissions	Provided assistance to 52 companies	130%
Control measures for the standards of permissible energy consumption of energy consuming facilities or apparatus	The estimated reduction from 2016 to 2020 is 1,301,500 tons of CO_2	The accumulated reduction reached 1,518,700 tons of CO_2 (29 product energy efficiency benchmarks have been announced by 2020)	116.69%
Certification and promotion of products with energy-saving label	The estimated reduction from 2016 to 2020 is 269,500 tons of CO_2	The accumulated reduction reached 559,700 tons of CO_2 (As of December 2020, 51 energy-saving label products have been announced)	207.69%

Source: 2020 Greenhouse Gas Emission Control Implementation Report for the residential and commercial sector, and the information provided by the Department of Commerce (Ministry of Economic Affairs), the Bureau of Energy (Ministry of Economic Affairs), and the Construction and Planning Agency (Ministry of the Interior)

promotion of green building regulations and labels, energy efficiency management of construction equipment, mandatory control measures for the service industry, counseling for specific targets, promotion of independent carbon reduction in the service industry, incentives and subsidies, etc. The progress for implementing the assessment indicators and other quantitative indicators for the residential and commercial sector is summarized as shown in Table 3.3.3-4:

5. Agricultural sector

The Action Programs for the agricultural sector is governed by the Council of Agriculture, Executive Yuan, with a total of 3 promotion

Table 3.3.3-5: Progress of implementing the assessment indicators for the agricultural sector

Assessment indicator	2020 Goal	2020 Progress	Progress percentage (%)
organic and environmentally-friendly farming area	Environmentally-friendly farming area reaches 15,000 hectares	15,754 hectares of Environmentally-friendly farming area was reached	105.03%
Promoting the reuse of livestock farm biogas (power generation)	The total number of livestock accounts for 50% of the total number of livestock being nurtured (estimated number of livestock is 2.5 million)	The total number of livestock reached 2.5 million	100%
Completing afforestation	The targeted afforestation area is 3,636 hectares	3,207 hectares	88.20%

Source: the Climate Talks platform, and the 2020 Greenhouse Gas Emission Control Implementation Report for the agricultural sector

strategies and 8 specific measures or plans. The key tasks include increasing the area of organic and environmentally-friendly farming, promoting the reuse of livestock farm biogas (power generation), increasing the afforestation area, and formulating implementation or rewarding programs, strengthening various energy-saving and carbon-reduction measures, and reducing carbon emissions per unit agricultural production under the premise of ensuring the food security of our nation. The progress for implementing the assessment indicators and other quantitative indicators for the agricultural sector is summarized as shown in Table 3.3.3-5:

6. Environmental sector

Governed by the Environmental Protection Administration, Executive Yuan, the Action Programs for the environmental sector include a total of 35 specific measures or plans. The programs suggest that specific actions for building resilience and emission mitigation should be considered, when formulating, developing, and implementing policies and environmental assessments. These include implementing energy and resource recycling, creating a shared economic society, enhancing the reuse of regional energy resources, and reducing the emission of greenhouse gas during the treatment of waste and wastewater (sewage). The key tasks include reducing the emission of greenhouse gas due to the treatment processes of waste and wastewater (sewage), providing rewards to biogas power generation landfills for methane recycling and reuse, continuing the construction of sewage systems, and increasing the national sewage treatment rate to 60.8% in 2020. The progress for implementing the assessment indicators and other quantitative indicators for the environmental sector is summarized as shown in Table 3.3.3-6:

Table 3.3.3-6: Progress of implementing the assessment indicators for the environmental sector

Assessment indicator	2020 Goal	2020 Progress	Progress percentage (%)
National sewage treatment rate	Increase the national sewage treatment rate to 60.8%	64.5%	106.09%

Source: the Climate Talks platform, and the 2020 Greenhouse Gas Emission Control Implementation Report for the environmental sector

Table 3.3.3-7: Summary of Greenhouse Gas Reduction Policies

Sector	Goal	Policy type	Implement-ation status	Description	Year of implement-ation	Unit of governance	Expected benefit
Energy sector	Adjust energy structure and improve efficiency	Technology development/ subsidies/ regulations	Completed	● Revise the Renewable Energy Development Act, and improve the legal environment for promoting renewable energy ● Increase the installed capacity of renewable energy power generation equipment ● Increase LNG unloading capacity ● Promote energy verification and voluntary reduction measures for the energy industry to improve energy	From 2016 to 2020	Ministry of Economic Affairs	6,316,000 tons of CO_2e
Manu-facturing sector	Transform into a green and inno-vative en-terprise and implement sustainable production and con-sumption actions	Stand-ards/ technology de-velop-ment/ talent training	Completed	● Guide enterprises in transforming into green and low-carbon businesses and develop green energy industry ● Establish and improve the incentives for greenhouse gas reduction, and strengthen industrial reduction measures ● Allow the public to develop sustainable consumption habits and help the industry to adopt sustainable production processes	From 2016 to 2020	Ministry of Economic Affairs	4,000,000 tons of CO_2e
transporta-tion sector	Develop green transporta-tion and improve the energy ef-ficiency of the trans-portation system	Technolo-gy devel-op-ment/ regulations/ awareness en-hancement	Completed	● IDevelop public transportation system and strengthen transportation demand management ● Promote the use of low-carbon transportation vehicle and build a green transportation-oriented transportation environment ● Improve the energy efficiency of transportation systems and vehicles	From 2016 to 2020	Ministry of Trans-portation and Commu-nications	1,980,000 tons of CO_2e
Residential and commercial sector	Construct sustainable buildings and low-carbon living cir-cles	Regula-tions/ standards/ subsidies/ voluntary agree-ment/ awareness en-hancement	Completed	● Improve the energy-saving design benchmark value for the envelope of newly constructed buildings ● Strengthen the reduction management of existing buildings ● Plan and construct the carbon reduction capacity for the competent authorities of the service industry sector ● Improved efficiency of electricity use in public sector buildings	From 2016 to 2020	Ministry of Interior	3,328,200 tons of CO_2e
Agricultural sector	Promote sustainable agricultural management	Subsidies/ awareness enhancement/ regulations/talent training	Completed	● Promote organic and environmentally-friendly farming ● Promote the reuse of biogas from livestock farms ● Afforestation and strengthening forest management	From 2016 to 2020	Council of Agriculture	● Total agricultural carbon reduction: 136,910 tons of CO_2e ● Total carbon removal by afforestation: 42,590 tons of CO_2e

Sector	Goal	Policy type	Implement-ation status	Description	Year of implement-ation	Unit of governance	Expected benefit
Environ-mental sector	Reduce environ-mental load and build an energy/ resource recycling society	Regulations/ awareness enhancement/ talent training/	Completed	● Improve the national sewage treatment rate ● Strengthen methane recovery from waste landfills and industrial wastewater ● Carry out the sustainable recycling of materials and promote the recycling of energy/resources ● Establish greenhouse gas reduction regulations and supporting mechanisms	From 2016 to 2020	Environ-mental Protection Adminis-tration, Exec-utive Yuan	From 2018 to 2020, reduction of 1,500 tons of CO2e from methane recovery

Source: Website of national greenhouse gas reduction regulations; website of the Bureau of Energy

3.3.4 Greenhouse gas control implementation plans of the local governments

The Environmental Protection Administration, Executive Yuan, has established a long-term partnership with local governments to jointly develop climate change implementation plans. With the low-carbon sustainable homeland as the basis, local characteristics were incorporated to formulate and refine strategies for promoting the reduction and adaptation work, increasing the public's carbon reduction awareness and social carbon reduction potential.

1. Principles for formulating the implementation plans of the local governments

Article 15 of the Greenhouse Gas Management Act stipulates that competent authorities in the special municipality, county, and city levels shall develop "greenhouse gas control implementation plans (hereinafter referred to as the implementation plans)" in accordance with the Action Plan as well as the Action Programs for various sectors and such implementation plans shall be finalized after requesting the approval of the central competent authority in consultation with the central industry competent authorities. The content of the implementation plans includes plan goals, promotion schedule, promotion strategy, expected benefits, and management & evaluation mechanism, as shown in Figure 3.3.4-1.

Executive Program Structure	
Current Situation Analysis	● Environmental, social and economic conditions, emission characteristics, and driving conditions
Program Objectives	● Setting qualitative or quantitative targets to be achieved by 2020 in line with the promotion strategy
Promotion Period	● In line with the promotion program and action plan target period (2018 to 2020)
Promotion strategy (including organizers, co-organizers and funding)	● For reference, the Executive Yuan approved the promotion plan and action plan, the central and local cooperation matters, and local promotion policy research and development. ● The principles of the writing are as follows: ● Developing localized strategies based on local characteristics ● Prioritizing the actions of the housing and transportation sector by focusing on livelihood issues ● Promoting community participation and expand public-private partnerships ● Central and local cooperation and implementation through local governance ● Evaluating the strategy feasibility and cost effectiveness and determining the strategy's execution sequence ● Cross-bureau integration to promote the organization of a clear division of labor
Expected Benefits	● Presenting a vision or benefits that can be achieved
Mechanism for management examination	● Municipalities directly under the jurisdiction of the county (city) government should develop a management assessment mechanism.

Figure 3.3.4-1: Content of the implementation plans

Source: Website of national greenhouse gas reduction regulations

The principles for formulating the implementation plans include:

(1) Develop strategies based on local characteristics: The geographical environment and industrial structure of counties and cities are different; therefore, it is required to formulate carbon reduction measures that meet local needs.

(2) Focus on the issues of people's livelihood, and give priority to the promotion of actions for the residential, commercial and transportation sectors: Promote first carbon reduction actions that are related to people's livelihood, and strengthen public advocacy and communication, such as those in the residential, commercial and transportation sectors.

(3) Put forward strategies that are executable, quantifiable, and cost-effective: Put forward quantitative results and cost estimates for various measures, and arrange implementation priorities.

(4) Promote private participation and expand public-private collaboration: The public sector will take the lead in implementation and guide the private sector to join, promoting public participation, and establishing a collaborative consultation mechanism with the private sector.

(5) The central and local governments work together to carry out implementation through local governance: Take the Action Programs for the six major sectors of the central government as a reference, list out local challenges, and combine central and local resources.

(6) Cross-departmental integration and promotion, clear division of work: The climate change policies involve various departments and bureaus of the central and the local governments. It is recommended to establish a clear division of work, and management & evaluation mechanisms, and to organize a dedicated unit.

2. Highlights of the implementation plans of the local governments

Based on the content of the Action Plan and the Action Programs, while considering the characteristics of local governance, the local governments have formulated the implementation plans. In 2019, the implementation plans were approved by relevant units such as the Environmental Protection Administration in consultation with the Ministry of Economic Affairs, the Ministry of Transportation and Communications, the Ministry of Interior, and the Council of Agriculture. The implementation highlights of various counties and cities are shown in Figure 3.3.4-2. The carbon reduction measures by sectors are summarized as follows:

(1) Energy sector: utilize public land or public building space to install photovoltaic panels, improve power generation facilities, and use general industrial waste as fuel for power generation.

(2) Manufacturing sector: strengthen regional air pollution control, replace old boilers, and control the total amount of raw coal and heavy oil used.

(3) Transportation sector: promote the use of official electric vehicles and shared electric vehicles, increase the utilization rate of electric buses, set up public bicycles, and strengthen the transferring and shuttle services for public transportation.

(4) Residential and commercial sector: replace old energy-saving appliances with new ones, implement energy-saving measures, install green building roofs and walls to achieve greening and cooling effects, and promote water resource recycling and reuse.

(5) Agricultural sector: promote the reuse of biogas slurry and residues, replace chemical fertilizers, utilize agricultural waste as raw materials, and produce soil additives or other industrial raw materials.

(6) Environmental sector: improve local waste incineration or measures, improve resource recovery rate, and establish a circular-economy industrial chain.

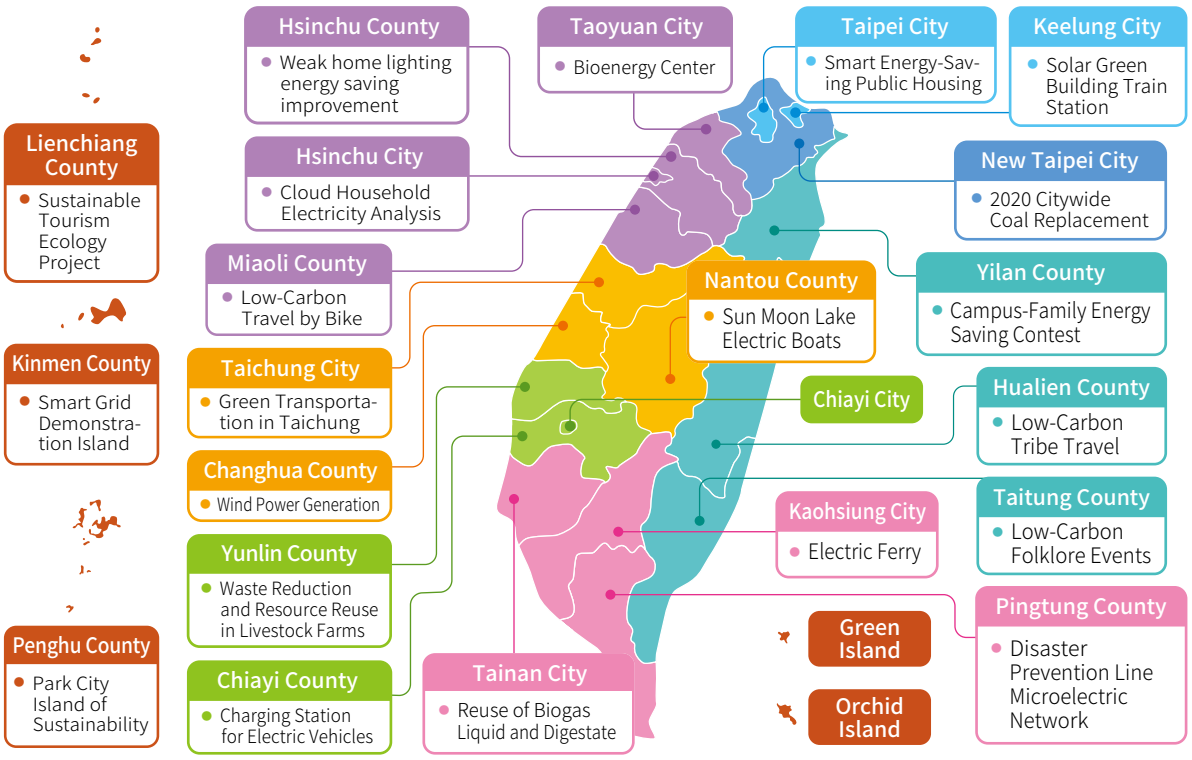

Figure 3.3.4-2: Highlights of the greenhouse gas control implementation plans of the local governments

Source: Website of national greenhouse gas reduction regulations

3.3.5 Evaluation of Taiwan's Pathway to Net-Zero Emissions

In view of the global trend towards net-zero emissions that has gradually taken shape in recent years, President Tsai Ing-wen announced on January 1, 2021, that the government would actively engage in dialogue with all walks of life to chart the pathway of Taiwan's climate governance and convert the challenges of carbon reduction into new opportunities for industrial investment and job creation, finding a new direction for the sustainable development of Taiwan. She also announced on Earth Day on April 22 that Taiwan's next step is to work towards the goal of "Net-Zero Emissions by 2050." In addition to the steady promotion of the energy transformation, systematic carbon reduction strategies must also be proposed for various sectors, including the manufacturing sector, transportation sector, residential and commercial sector, agricultural sector, etc.

Premier Su Tseng-chang also announced on Earth Day that under the goal of "Net-Zero Emissions by 2050," the Executive Yuan will further coordinate and evaluate possible ways to speed up and increase synchronization with the world to jointly build a sustainable green homeland. For this reason, the Office of Energy and Carbon Reduction of the Executive Yuan initiated the assessment for Taiwan's net zero emissions pathway, which formulated comprehensive plan on how to respond to the challenges of climate change from the perspectives of industry, environment, government governance, and national security, finding new industrial opportunities. At the same time, social dialogue was commenced by inviting all walks of life to jointly formulate Taiwan's "Thirty-Year Vision" towards 2050

1. Cross-departmental collaboration mechanism

The Office of Energy and Carbon Reduction established the "Net-Zero Pathway Task Force" in February 2021. The "Inter-Ministerial Coordination Group" was formed by the deputy ministers of the ministries and departments responsible for promoting climate-change policies, coordinating the division of work among various units in the evaluation work, and promoting the sharing and exchange of information among various units. To ensure that the policy evaluation process is based on a solid scientific foundation, the "Academia Sinica," the most recognized academic research institution in Taiwan, and the "Industrial Technology Research Institute," an important applied research institution in Taiwan, are selected as the advisory members to participate in various discussions and provide professional advice as appropriate.

In terms of implementation, the responsible ministries and departments of various issues and the research teams of relevant think tanks in Taiwan will conduct researches on the model simulation and scenario analysis for greenhouse gas net-zero emissions. They are mainly divided into three mechanisms: "five major working groups," the "model group" and the "vision group."

(1) Five major working groups

The main tasks of the five major working groups are the policy planning, integration, coordination, and promotion of Taiwan's net-zero emission pathways. Key technologies are used as the category to establish an inter-ministerial coordination group, and integrate the net-zero emission pathways planned by various ministries and departments separately for the issues of concern. The content includes stakeholder negotiation, key parameters and technology portfolio assessment, and the schedule for regulation planning and policuy promotion.

(2) Vision group

The main task of the vision group is to carry out social dialogue and vision imagination on the current status and problems of Taiwan's net zero emission pathway. The Environmental Protection Administration is responsible for the coordination and promotion, inviting stakeholders to discuss the key issues of net-zero emission.

(3) Model group

The main task of the model group is to perform

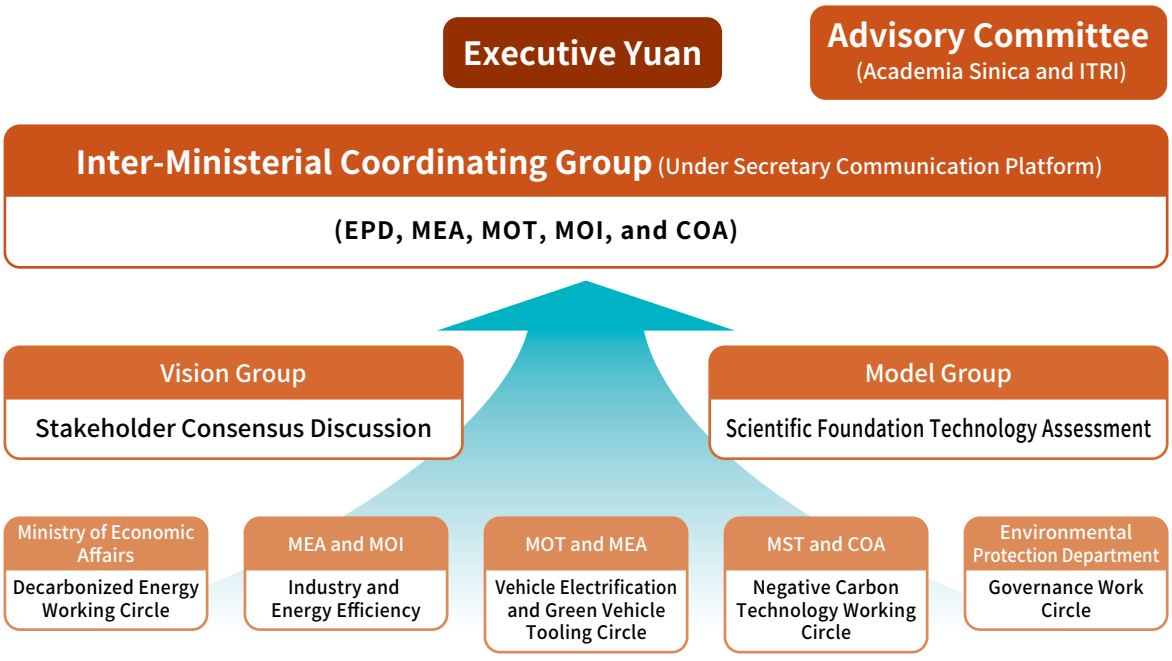

Figure 3.3.5-1: Organizational structure of the "Net-Zero Pathway Task Force"

Source: Environmental Protection Administration, Executive Yuan

scenario simulation and path evaluation for Taiwan's net-zero emission pathway, which is conducted jointly by the three major model teams in Taiwan, including the economic model (TAIGEM), the energy engineering model (TIMES) and the environmental engineering model (LEAP).

The overall structure of the Net-Zero Pathway Task Force mentioned above is shown in Figure 3.3.5-1.

2. Five supporting measures for transformation

(1) Social system: comprehensively review the laws and regulations, steadily replace old technologies, and provide a good environment for testing and developing new technologies.

(2) Green funds: Public sector funds should prioritize supporting green products and technologies, implement carbon pricing, and accelerate private sector investment.

(3) Behavioral change: Let the public fully understand the challenges and opportunities of climate change starting from education, making them to support green products and government policies. Incorporate social communication and dialogue into the formulation and promotion of policies.

(4) Transformation with fairness and justice: By actively managing the risks of unemployment and poverty arising from the transformation process, we can achieve a net-zero emission that does not leave anyone behind.

(5) International collaboration: As an important part of the global supply chain, Taiwan should work with important trading partners (the United States, Japan, and Europe) to formulate carbon reduction strategie

3. Social communication and dialogue

Social dialogue is implemented in cooperation with the pathway planning schedule of the five major working groups so that the key issues of policy implementation in the technical, policy, economic and social aspects can be fully grasped. Six vision working group seminars have been held, involving 110 representatives from industries, universities, research institutes, and non-governmental organizations. The progress of the implementation of social dialogue for various work circle and cross-work circle issues is shown in Figure 4.5-3:

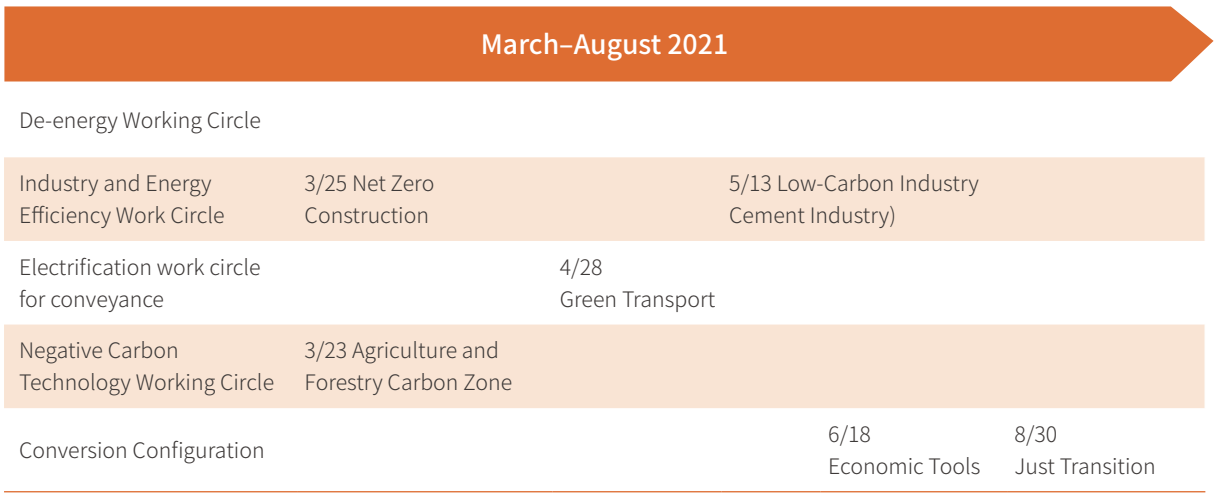

Figure 3.3.5-2: progress of social dialogue conducted by the "Net-Zero Pathway Task Force"

Source: Environmental Protection Administration, Executive Yuan

References

1. Ministry of Interior, "Greenhouse Gas Emission Control Action Programs for the Residential and Commercial Sector," 2018: https://ghgrule.epa.gov.tw/action/action_page/52.
2. Ministry of Interior, "Greenhouse Gas Emission Control Implementation Report for the Residential and Commercial Sector," 2020: https://ghgrule.epa.gov.tw/action/action_page/52.
3. Website of the Legislative Yuan: https://www.

ly.gov.tw/Home/Index.aspx.

4. Website of national greenhouse gas reduction regulations, Environmental Protection Administration, Executive Yuan: https://ghgrule.epa.gov.tw/front/.
5. Website of the Executive Yuan: https://www.ey.gov.tw/index/.
6. Climate Talks website of the Environmental Protection Administration, Executive Yuan: https://www.climatetalks.tw/.
7. Website of the National Council for Sustainable Development: https://nsdn.epa.gov.tw/.
8. Office of Energy and Carbon Reduction, Executive Yuan: https://www.ey.gov.tw/oecr/.
9. Environmental Protection Administration, Executive Yuan, "National Climate Change Action Guideline," 2017: https://ghgrule.epa.gov.tw/action/action_page/50.
10. Environmental Protection Administration, Executive Yuan, "Greenhouse Gas Reduction Action Plan," 2018: https://ghgrule.epa.gov.tw/action/action_page/51.
11. Council of Agriculture, Executive Yuan, "Greenhouse Gas Emission Control Action Programs for the Agricultural Sector," 2018: https://ghgrule.epa.gov.tw/action/action_page/52.
12. Environmental Protection Administration, Executive Yuan, "Greenhouse Gas Emission Control Action Programs for the Environmental Sector," 2018: https://ghgrule.epa.gov.tw/action/action_page/52.
13. Council of Agriculture, Executive Yuan, "Greenhouse Gas Emission Control Implementation Report for the Agricultural Sector," 2020: https://ghgrule.epa.gov.tw/action/action_page/52.
14. Environmental Protection Administration, Executive Yuan, "Greenhouse Gas Emission Control Implementation Report for the Environmental Sector," 2020: https://ghgrule.epa.gov.tw/action/action_page/52.
15. Ministry of Transportation and Communications, "Greenhouse Gas Emission Control Implementation Report for the Transportation Sector," 2020: https://ghgrule.epa.gov.tw/action/action_page/52.
16. Ministry of Transportation and Communications, "Greenhouse Gas Emission Control Action Programs for the Transportation Sector," 2018: https://ghgrule.epa.gov.tw/action/action_page/52.
17. Website of Financial Supervisory Commission: https://www.fsc.gov.tw/ch/index.jsp.
18. Taoyuan City Government, "Taoyuan City Greenhouse Gas Control Implementation Plan, 2019: https://ghgrule.epa.gov.tw/action/action_page/53.
19. Kaohsiung City Government, "Kaohsiung City Greenhouse Gas Control Implementation Plan, 2019: https://ghgrule.epa.gov.tw/action/action_page/53.
20. Ministry of Economic Affairs, "Greenhouse Gas Emission Control Action Programs for the Energy Sector," 2018: https://ghgrule.epa.gov.tw/action/action_page/52.
21. Ministry of Economic Affairs, "Greenhouse Gas Emission Control Action Programs for the Manufacturing Sector," 2018: https://ghgrule.epa.gov.tw/action/action_page/52.
22. Ministry of Economic Affairs, "Greenhouse Gas Emission Control Implementation Report for the Energy Sector," 2020: https://ghgrule.epa.gov.tw/action/action_page/52.
23. Ministry of Economic Affairs, "Greenhouse Gas Emission Control Implementation Report for the Manufacturing Sector," 2020: https://ghgrule.epa.gov.tw/action/action_page/52.
24. New Taipei City Government, "New Taipei City Greenhouse Gas Control Implementation Plan, 2019: https://ghgrule.epa.gov.tw/action/action_page/53.
25. Taipei City Government, "Taipei City Greenhouse Gas Control Implementation Plan, 2019: https://ghgrule.epa.gov.tw/action/action_page/53.
26. Taichung City Government, "Taichung City Greenhouse Gas Control Implementation Plan, 2019: https://ghgrule.epa.gov.tw/action/action_page/53.
27. Tainan City Government, "Tainan City Greenhouse Gas Control Implementation Plan, 2019: https://ghgrule.epa.gov.tw/action/action_page/53

Chapter 4

Greenhouse Gas Emission Prediction

4.1 Emission pathway prediction
4.2 Reduction effectiveness evaluation
4.3 Prediction method

Chapter 4 Greenhouse Gas Emission Prediction

With the long-term reduction targets set by the "Greenhouse Gas Reduction and Management Act," periodic regulatory goals are set every five years to promote the implementation of Taiwan's reduction policies gradually. To properly set the periodic regulatory goals, the greenhouse gas emission pathways of Taiwan and various sectors are predicted based on the reduction potential of the energy-saving and carbon-reduction strategies of various sectors. The following describes the prediction of the greenhouse gas emission pathway, the evaluation of the reduction effectiveness of policies and measures, and related methodologies.

4.1 Emission pathway prediction

When the Environmental Protection Administration, Executive Yuan set the Phase I Periodic Regulatory Goals, it consulted with the central industry competent authority to formulate the national greenhouse gas emission trend estimation principles and parameter specifications in accordance with Article 7, Paragraph 1 of the "Regulations for Periodic Regulatory Goals and Approaches of the Greenhouse Gas Emissions." The scope of the gas type, emission type, and prediction period is defined as follows: (summarized as shown in Table 4.1.1-1)

I.Gas type

Greenhouse gases include seven kinds of gas: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). They are all converted into carbon dioxide equivalent (CO_2e) according to the global warming potential (GWP) of the greenhouse gases.

II. Emission type

According to the "National Greenhouse Gas Inventory Report," greenhouse gas emissions (or removal) are divided into three types, including fuel combustion greenhouse gas emissions (energy), non-fuel combustion greenhouse gas emissions (industrial processes and product use sector, agricultural sector, waste sector) and carbon sinks (land use, land use change, and forestry sector).

III.Sector classification

The implementation of Taiwan's "Greenhouse Gas Reduction and Management Act" is divided into six major sectors. The energy sector manages renewable energy development, energy efficiency improvement, and energy conservation. The manufacturing sector manages industrial greenhouse gas reduction. The transportation sector covers transportation management, mass transit system development, low-carbon energy transportation and other transportation greenhouse gas emission reduction. The residential and commercial sector manages to build greenhouse gas reduction. The agricultural sector is responsible for forest resource management, strengthening forests' carbon sequestration, and reducing agricultural greenhouse gas. The environmental sector manages waste recycling and reuse. The sector classification described in this section differs from the "National Inventory Report." Greenhouse gas emissions from electricity use will be returned to each electricity sector.

IV.Prediction period

Based on the "Phase II Periodic Regulatory Goals (Draft)" completed on September 29, 2021, a prediction is made on Taiwan's greenhouse gas emission pathways from 2020 to 2035.

Table 4.1.1-1: Description of the defined scope

Scope	Description
Gas type	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3)
Emission type	Fuel combustion greenhouse gas emissions, non-fuel combustion greenhouse gas emissions (industrial processes and product use sector, agricultural sector, waste sector), and carbon sinks (land use, land use change, and forestry sector)
Sector classification	Energy, manufacturing, transportation, residential & commercial, agricultural, environmental sectors
Prediction period	From 2020 to 2035

Source: Environmental Protection Administration, Executive Yuan.

4.2 Reduction effectiveness evaluation

In this section, the effectiveness of Taiwan's greenhouse gas reduction is evaluated under the "With Existing Measures' Scenario." The "With Existing Measures' Scenario" includes all the policies and measures that have been implemented and passed in Taiwan

Under the "With Existing Measures' Scenario" and using 2005 as the base year, it is expected to reduce greenhouse gas emissions by 2% in 2020, 10% in 2025, 20% in 2030, and 25-30% in 2035, so that the statutory target of 50% reduction by 2050 can be achieved.

Table 4.2-1: The GHG net emission pathway under the "With Existing Measures' Scenario"

Unit: $MtCO_2e$	Predicted value			
	2020	2025	2030	2035
Base year (2005) Net emission (A)	268.634	268.634	268.634	268.634
GHG net emission pathway under the "With Existing Measures' Scenario"(B)	260.717	241.011	214.232	227.622~187.453
GHG reduction credit (B-A)	7.917	27.623	54.402	41.012~81.181

Source: Environmental Protection Administration, Executive Yuan, "National Greenhouse Gas Inventory Report of the Republic of China (2021 Edition)," 2021; Bureau of Energy, Ministry of Economic Affairs, "2019 Statistics on CO_2 Emissions from Fuel Combustion," 2020; Bureau Energy, Ministry of Economic Affairs, "Explanation on the estimation of Greenhouse Gas Emissions from Fuel Combustion," 2020; Environmental Protection Administration, Executive Yuan, "Statistics and Trend Prediction of Greenhouse Gas Emissions from Non-fuel Combustion," 2019

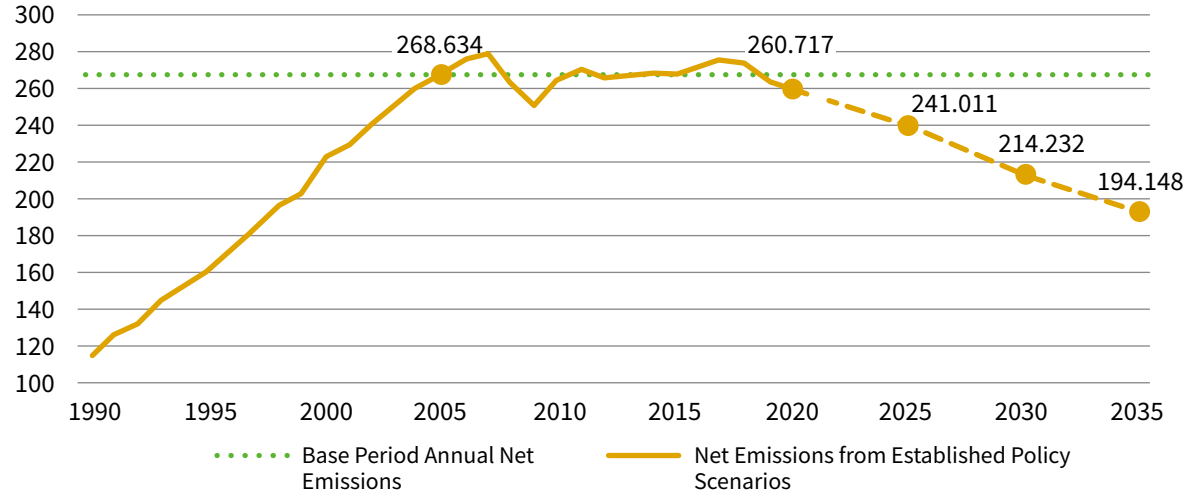

Figure 4.2-1: Comparison of the pathways of net greenhouse gas emissions

Note: The data from 1990 to 2019 are actual performance values, and the data after 2020 are estimated values

Source: Environmental Protection Administration, Executive Yuan, "National Greenhouse Gas Inventory Report of the Republic of China (2021 Edition)," 2021; Bureau of Energy, Ministry of Economic Affairs, "2019 Statistics on CO_2 Emissions from Fuel Combustion," 2020; Bureau Energy, Ministry of Economic Affairs, "Explanation on the estimation of Greenhouse Gas Emissions from Fuel Combustion," 2020; Environmental Protection Administration, Executive Yuan, "Statistics and Trend Prediction of Greenhouse Gas Emissions from Non-fuel Combustion," 2019.

4.3 Prediction method

The planning of Taiwan's greenhouse gas emission pathway is based on the summation of various sectors' greenhouse gas emission pathways. The competent authorities of various sectors estimate the energy consumption and greenhouse gas emissions based on unified parameter assumptions (economic growth, population) and plan corresponding energy-saving and carbon-reduction strategies. Regarding greenhouse gas emissions from fuel combustion, the Bureau of Energy, Ministry of Economic Affairs, will make predictions after planning the energy supply based on the country's energy consumption and strategic energy savings. As for the greenhouse gas emissions from non-fuel combustion, the Environmental Protection Administration, Executive Yuan compiles the predicted data of various sectors. The Council of Agriculture ,, Executive Yuan, is responsible for predicting carbon sinks. The national greenhouse gas emission pathway prediction process is shown in Figure 4.3-1.

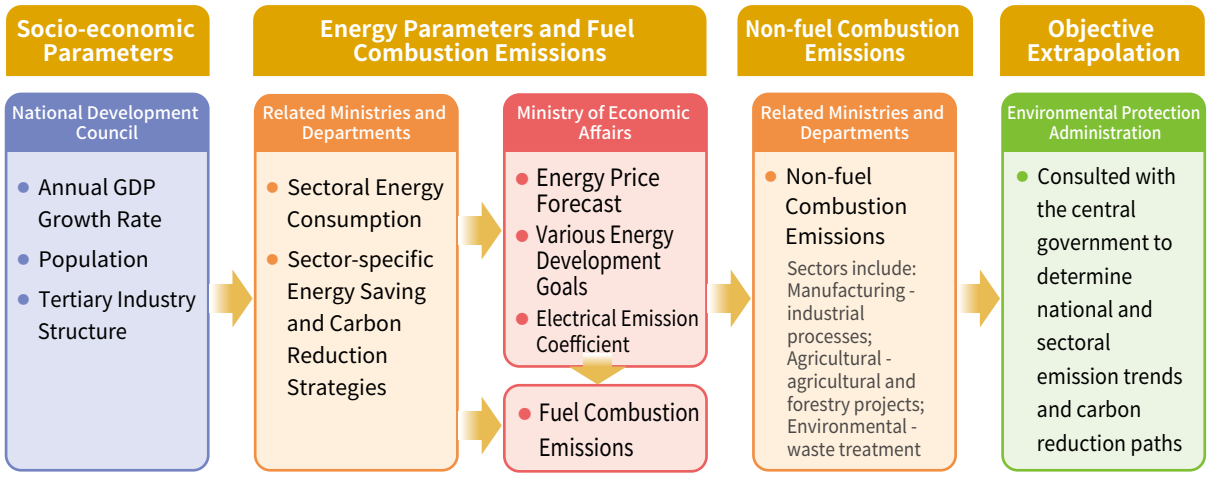

Figure 4.3-1: Greenhouse gas emission pathway prediction process

Source: Environmental Protection Administration, Executive Yuan, "Phase I Greenhouse Gas Periodic Regulatory Goals," 2018

4.3.1 Parameter assumptions

To allow the simulation of greenhouse gas emissions of each sector to be carried out under a consistent baseline scenario, parameter assumptions are set for indicators such as overall economic growth, population, and energy, as described below:

I. Prediction of gross domestic product (GDP)

The National Development Council comprehensively considers domestic and foreign economic development trends, including population, international energy prices, international economic and trade environment, total factor productivity, and industrial development trends, as well as policy directions provided by the competent authorities of various industries, to estimate Taiwan's medium and long-term GDP and the percentage for the three types of industries.

From the prediction conducted in August 2018, the overall economic growth rate in 2020 will be 2.49%, with the service industry accounting for the highest percentage of GDP (62.60%), followed by the manufacturing industry (accounting for 35.57%), and the agricultural industry (accounting for 1.82%). The overall economic growth rate in 2025 will rise to 2.65%, and the contribution of the service industry to GDP will continue to increase (accounting for 62.82%), while that of the manufacturing industry (accounting for 35.46%) and the agricultural industry (accounting for 1.72%) will decline. The National Development Council's prediction of Taiwan's economic growth rate and changes in the structure of the three types of industries is shown in Table 4.3.1-1.

Table 4.3.1-1: Prediction of Taiwan's economic growth rate and the percentage for the three types of industries

Year	Economic growth	Percentage of the three types of industries		
		Agricultural industry	Manufacturing industry	Service industry
2021	2.49%	1.82%	35.57%	62.60%
2022	2.56%	1.81%	35.55%	62.64%
2023	2.56%	1.79%	35.51%	62.71%
2024	2.65%	1.76%	35.48%	62.76%
2025	2.65%	1.72%	35.46%	62.82%

Source: National Development Council

II. Population projection

According to the "Population Projections for the R.O.C. (Taiwan): 2018-2065" issued by the National Development Council on August 30, 2018, the internationally used Cohort-Component Method was adopted to carry out population projection. It used the male and female populations at the end of 2017 as the base period and added assumptions such as births, deaths, and net international migration (including the move-in/move-out household registration of natives and foreigners) to increase the age of each person year by year, predicting the future male and female population of a single age.

The projection shows that the total population of Taiwan will reach a peak of 23.61 million people in 2020. Under three different hypothetical scenarios of a low, medium, and high projection, the total population in 2065 will fall between16.01 million and 18.8 million people, about a 20% to 30% reduction compared with 2018. The medium projection will be used as the basis for predicting the pathway of greenhouse gas emissions. The trend of Taiwan's total population growth is shown in Figure 4.3.1-1.

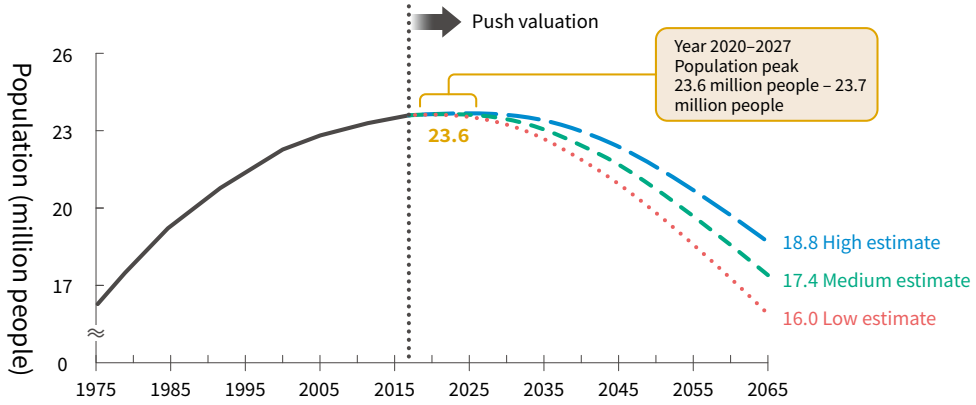

Figure 4.3.1-1: Trend of total population growth (under the scenarios of low, medium, and high projection)

Source: National Development Council, "Population Projections for the R.O.C. (Taiwan): 2018-2065," 2018

III.Energy transformation policy

To move towards the goal of a Nuclear-free Homeland and fulfill international carbon reduction commitments, in response to the rapid changes and challenges of domestic/foreign political and economic situations and the energy environment, Taiwan has implemented energy transformation policies to reduce coal and oil-fired power generation, and increase the percentage of low-carbon energy (gas and renewable energy) power generation.

It is planned that by 2025, the percentage of coal-fired, gas-fired and renewable energy power generation will reach 27.5%, 49.5%, and 20.3%, respectively. At the same time, nuclear power generation units whose operating life has expired will be gradually phased out. It is estimated that most nuclear power generation units will be phased out in 2025. The power generation structure pathways of various power plants are shown in Figure 4.3.1-2 and Table 4.3.1-2.

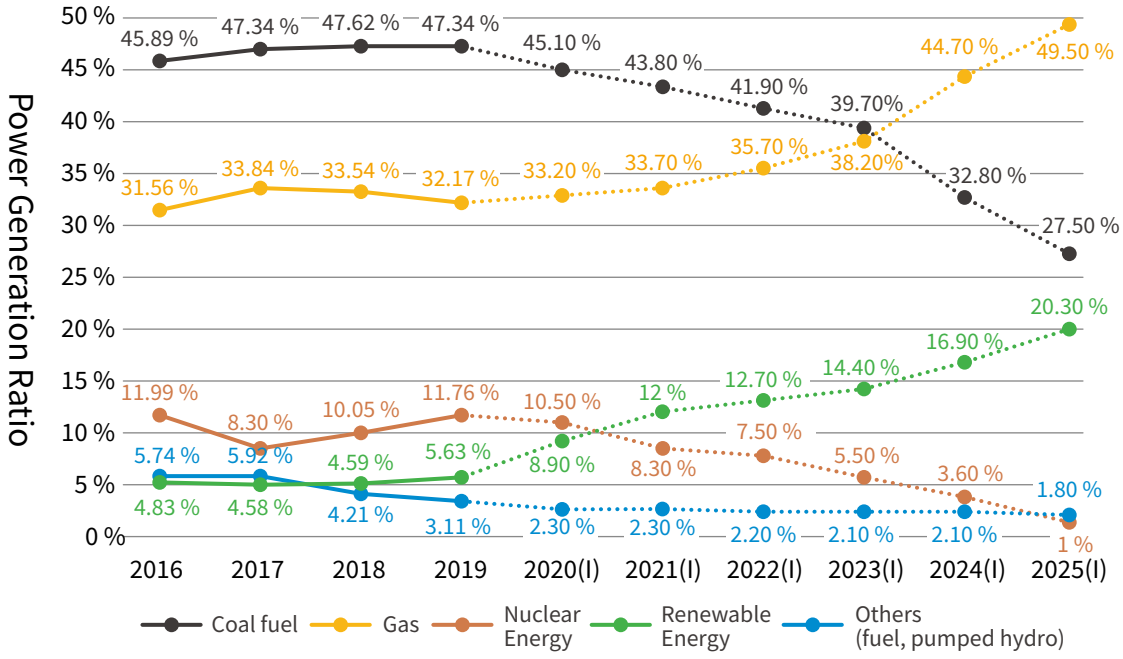

Figure 4.3.1-2: Power generation structure pathways of various power plants

Source: Bureau of Energy, Ministry of Economic Affairs

The unloading capacity target of imported natural gas are shown in Table 4.3.1-3 and Table 4.3.1-4. It will reach 26.2 million tons in 2025 and increase to 35.9 million tons in 2030. The percentage of gas-fired power generation will increase year by year, rising from 33.2% in 2020 to 49.5% in 2025. On the other hand, the percentage of coal-fired power generation will decline year by year, dropping from 45.1% in 2020 to 27.5% in 2025. The installed capacity of renewable energy is targeted at 35,373 MW for 2030. The power generation from renewable energy in 2020 accounted for 8.9% and will be increased to 20.3% in 2025.

Table 4.3.1-2: Operating life of nuclear power generation units

Operation setting / Unit	Date of closure	Decommissioning after retirement
Unit #1 of Chinshan Nuclear Power Plant	December 10, 2014	December 2018
Unit #2 of Chinshan Nuclear Power Plant	June 30, 2017	July 2019
Unit #1 of Kuosheng Nuclear Power Plant	March 2021	December 2021
Unit #2 of Kuosheng Nuclear Power Plant	March 2023	March 2023
Unit #1 of Maanshan Nuclear Power Plant	July 2024	July 2024
Unit #1 of MaanshanNuclear Power Plant	May 2025	May 2025

Source: Bureau of Energy, Ministry of Economic Affairs

Table 4.3.1-3: Volume of natural gas planned

Unit:10,000 tons

Year / Item	2020	2025
Unloading capacity	1,650	2,620

Source: Bureau of Energy, Ministry of Economic Affairs

Table 4.3.1-4: Volume of natural gas planned

Unit: MW

Year / Item	2020	2025
Solar photovoltaic	6,500	20,000
Onshore wind power	814	1,200
Offshore wind power	976	5,738
Geothermal energy	150	200
Biomass energy	768	813
Hydropower	2,100	2,150
Hydrogen energy and fuel cell	22	60
Ocean energy	0	0
Total	11,331	30,161

Source: Bureau of Energy, Ministry of Economic Affairs

Table 4.3.1-5: Power generation from renewable energy

Unit: 100 GWh

Item \ Year	2020	2025
Solar photovoltaic	81	256
Onshore wind power	19	28
Offshore wind power	35	207
Geothermal energy	10	13
Biomass energy	38	43
Hydropower	64	66
Hydrogen energy and fuel cell	2	5
Ocean energy	0	0
Total	249	617

Source: Bureau of Energy, Ministry of Economic Affairs

4.3.2 Prediction method

The prediction methods used for fuel combustion greenhouse gas emissions, non-fuel combustion greenhouse gas emissions, and forest carbon sink greenhouse gas removal are described as follows:

I. Fuel combustion greenhouse gas emissions

The Ministry of Economic Affairs introduced the energy engineering model, MARKAL, of the International Energy Agency in 1993 and modified it to create the Taiwan TIMES (The Integrated MARKAL-EFOM System) model in 2010. Through detailed and flexible modeling functions, it has conducted evaluations for several major energy policies in Taiwan. The TIMES model is a linear programming model stacked from bottom to top with huge and complex energy technologies. Since energy demand is an exogenous driving force, the TIMES model can be used to plan the scenarios for the development of the energy system under the balance of energy supply and demand, environment and resource constraints, and the goal of minimizing the cost of the energy system.

To thoroughly investigate the interaction between energy policy, economic and environmental aspects, the TIMES model team of the Bureau of Energy continues to develop the energy, economy, and environment integrated TISMO model (Taiwan Integrated Sustainability Model). It uses Taiwan's TIMES model as the core to build the overall economic model, TISMO-CGE, and the environmental impact assessment module, TISMO-ENV, expanding the integration assessment function of the TIMES model through a soft link and using it as a tool for predicting the greenhouse gas emissions from fuel combustion across the country from 2021 to 2025. The structure of the TISMO integrated model is shown in Figure 4.3.2-1.

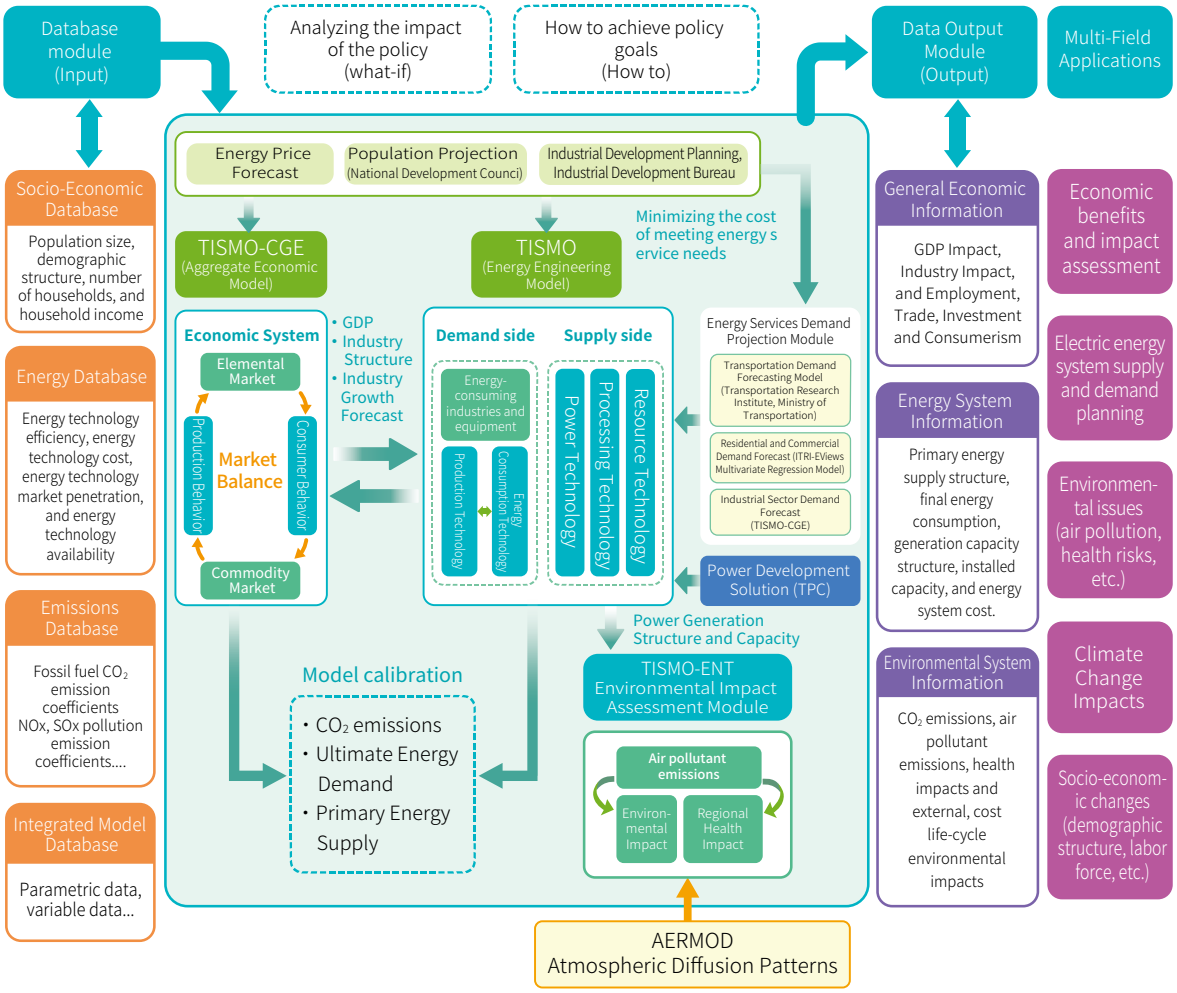

Figure 4.3.2-1: Structure of the TISMO integrated model

Source: Energy Knowledge Bank of the Bureau of Energy, Ministry of Economic Affairs

II. Non-fuel combustion greenhouse gas emissions

● Industrial sector

The prediction of greenhouse gas emissions from non-fuel combustion of the industrial sector is conducted separately based on the production characteristics of industries. The prediction methods for various industries are explained as follows:

1. Information electronics industry

(1)Prediction is carried out based on the "first batch of emission sources that should be checked and registered for greenhouse gas emissions" electronic industry inventory application data, the industry growth estimates of the National Development Council, and the industry investment plans.

(2)Considering that the fluorine gas reduction of existing plants will gradually increase from the current 83% to 90%, the prediction will be conducted based on the condition that the total reduction of fluorine gas for new plants in the future will reach 90%.

2. Basic metal industry, basic non-metal industry, chemical material manufacturing, cement, and cement product industry, and glass and glass product manufacturing: Refer to historical trends, the industry growth estimates of the National Development Council, industrial policy goals,

and use an econometric model to carry out the prediction.

3..Use of substitutes for ozone-depleting substances: Prediction is conducted based on an average annual growth rate of 2.8% in the past three years (2013-2015)

● Agricultural sector

The prediction method for the greenhouse gas emissions of the agricultural sector mainly adopts the model jointly developed by the Center for Sustainable Science of the Academia Sinica and the Australian Bureau of Agriculture and Resource Economics and Sciences (ABARES). The General Equilibrium Model for Taiwanese Economy and Environment (GEMTEE,) established based on a Computable General Equilibrium (CGE) model, is used to predict the trend of greenhouse gas emissions from the top-down. Then the Taiwan Agricultural Sector Model (TASM) and the Taiwan Fishery Sector Model (TFSM) are used to perform detailed bottom-up calibration while considering parameters such as future socio-economic development trends and energy price growth. In the process, an expert symposium is held to collect experts' practical experience and opinions for making detailed corrections. The m odules are shown in Figure 4.3.2-2 and 4.3.2-

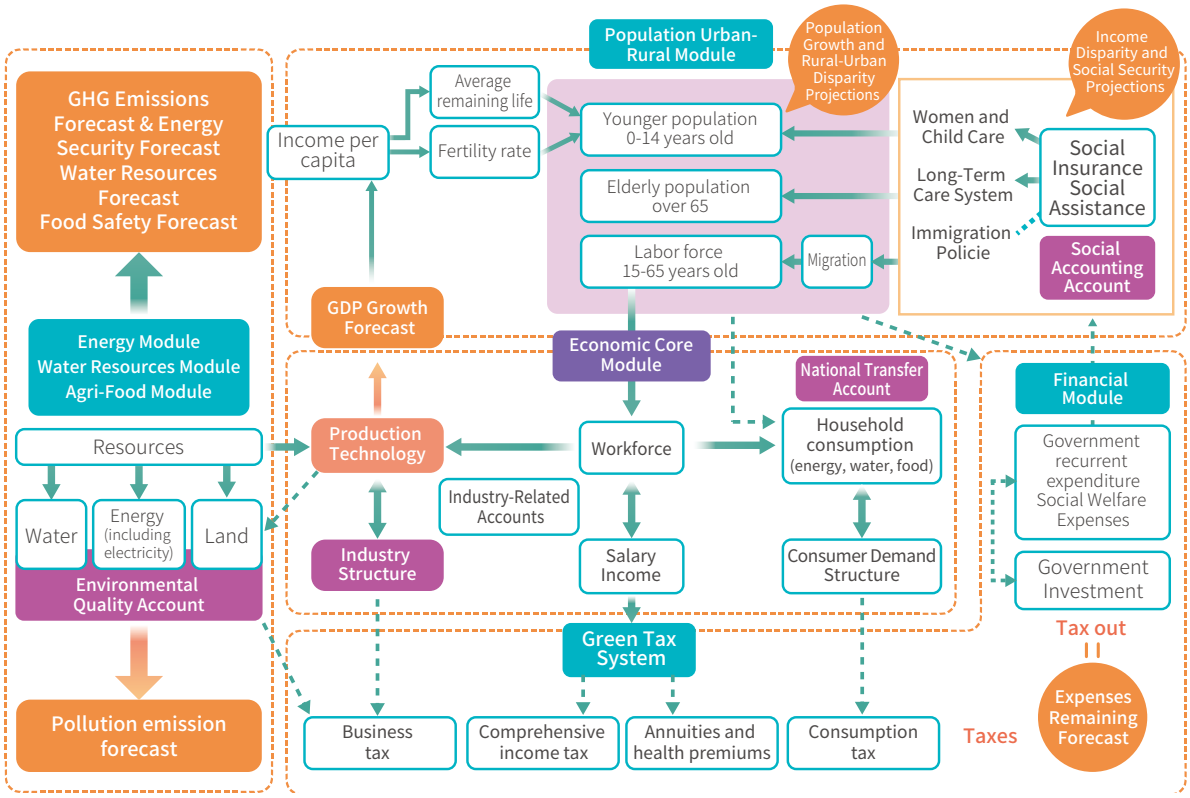

Figure 4.3.2-2: GEMTEE policy analysis module for agriculture sector

Source: Council of Agriculture, Executive Yuan, "Prediction of Greenhouse Gas Emissions from Non-fuel Combustion in Taiwan's Agricultural Sector," 2017

● Environmental sector

Greenhouse gas emission sources in the environmental sector include landfill, composting, incineration, and wastewater. The first three emission sources are mostly affected by waste treatment policies, while the fourth is directly related to population and economic activities. To rationalize the greenhouse gas emissions of the environmental sector, as to the prediction principles, if there is a clear trend of change, use the trend of activity data in the past years for prediction. If there is no clear trend of change, use the average activity data of the years with fewer changes within the recent past; and consider the impact of future environmental protection policies on changes in the activity data to predict the emission factor of the most recent year.

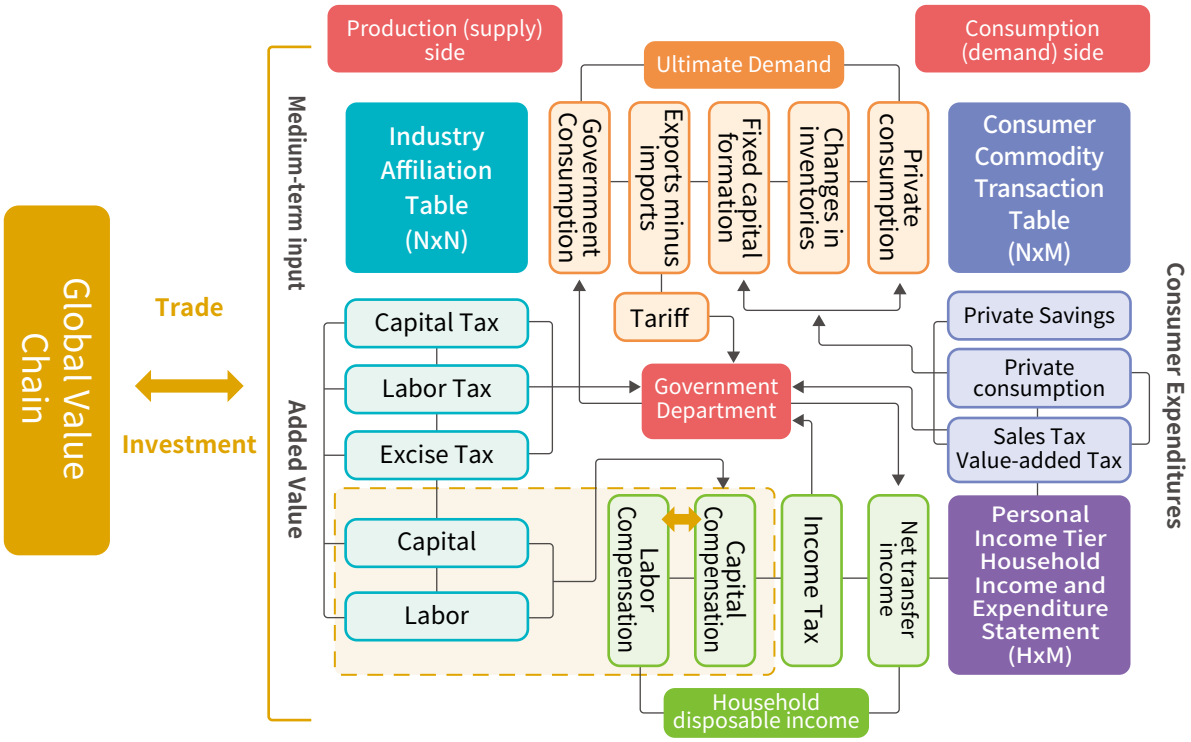

Figure 4.3.2-3: GEMTEE database structure of the agricultural sector

Source: Council of Agriculture, Executive Yuan, "Prediction of Greenhouse Gas Emissions from Non-fuel Combustion in Taiwan's Agricultural Sector," 2017

Based on the above principles, the methods for predicting the emission from various sources are as follows:

1. Emission from landfill disposal: the amount of sanitary landfill is predicted by using the power function from 2006 to 2015, and the amount of methane recovered is predicted using an exponential function from 2007 to 2015. The amount of general landfill is predicted based on the average landfill volume in the past eight years from 2008 to 2015.
2. Domestic sewage discharge: The sewage treatment rate is based on the value estimated by the Construction and Planning Agency, Ministry of the Interior from 2017 to 2020, and the population is based on the population projection value. The annual treatment capacity of all sewage plants in Taiwan is estimated by the linear function of the treatment capacity from 2009 to 2015. The protein supply per person per day is estimated based on the average value of the past 12 years from 2004 to 2015.
3. Composting: Prediction is based on the trend line from 2011 to 2015 in the past five years.
4. Incineration: Prediction is based on the average value from 2011 to 2015 in the past five years.
5. Industrial wastewater: Chemical Oxygen Demand (COD) removal is predicted based on the average value of the past nine years from 2007 to 2015, and total nitrogen (TN) emissions are predicted based on the average value of the past three years from 2013 to 2015.

● Forestry sector

1. Carbon sink trend prediction method

Forest carbon sinks are mainly the sum of the "forest for maintaining forest land" and "other land converted into forest land." The carbon sequestration of the "forest for maintaining forest land" accounts for more than 90% of the total forest carbon sequestration. Due to the implementation of the "Regional Plan Act" and the "Forestry Act" as well as other laws and policies that forbid logging of natural forests in the past 20 years, forest carbon sinks have generally been stable over the years. Assuming that there will be no major changes in the future afforestation policy, the average value of each

forest type in the forest resources survey in the past ten years will be used as the basic value for future prediction. The carbon sink losses caused by bamboo logging, forest fires, illegal logging, and indiscriminate reclamation are based on the average value of the past three years as the basis for future prediction. The "other land converted into forest land" is the result of afforestation over the years, and after 20 years, it is included in the forest area for maintaining forest land.

2. Scenario setting for carbon sequestration prediction

Carbon sinks mainly come from the "forest for maintaining forest land" and are affected by policies. When future policies are set to remain unchanged, changes in carbon sinks mainly come from the loss of carbon sinks from collapse. Therefore, the condition of "not considering collapse" and "considering collapse" will be adopted to carry out forest carbon sink trend prediction, resulting respectively a "High Case" and a "Low Case" prediction scenario.

(1) Scenario 1 "High Case": This scenario assumes that the government can take preventive measures against collapsed areas in Taiwan so that the forest land will not collapse. Therefore, Scenario 1 assumes that the forest land will not collapse in the future, and the area of each forest type of the "forest for maintaining forest land" is the average for the past ten years.

(2) Scenario 2 "Low Case": The "forest for maintaining forest land" considers the collapse condition every year. The collapse area of each forest type is assumed to be the average value of the past three years, and the vegetation will recover after ten years.

References

1. Environmental Protection Administration, Executive Yuan, "Phase I Greenhouse Gas Periodic Regulatory Goals," 2018: https://ghgrule.epa.gov.tw/greenhouse_control/greenhouse_control_page/36
2. Environmental Protection Administration, Executive Yuan, "2020 Republic of China National Inventory Report," 2020: https://unfccc.saveoursky.org.tw/nir/tw_nir_2020.php
3. Environmental Protection Administration, Executive Yuan, "Briefing on Phase II Greenhouse Gas Periodic Regulatory Goals (Draft)," 2020: https://8158f5bd-8e25-4af2-b99c-9089e9c815e2.filesusr.com/ugd/81796e_97e3916cdbd44a4c9f33f4e8bb79e6eb.pdf
4. Council of Agriculture, Executive Yuan, "Prediction of Greenhouse Gas Emissions from Non-fuel Combustion in Taiwan's Agricultural Sector," July 11, 2017
5. National Development Council, "Population Projections for the R.O.C. (Taiwan): 2018-2065," 2018: https://pop-proj.ndc.gov.tw/download.aspx?uid=70&pid=70
6. Bureau of Energy, Ministry of Economic Affairs, "Briefing of the Energy Sector for the Public Hearing of Phase II Greenhouse Gas Periodic Regulatory Goals," 2020: https://8158f5bd-8e25-4af2-b99c-9089e9c815e2.filesusr.com/ugd/81796e_96434ea18efa41adb76f45e44137414b.pdf
7. Bureau of Energy, Ministry of Economic Affairs, "2019 Statistics on CO_2 Emissions from Fuel Combustion," 2020: https://www.moeaboe.gov.tw/ecw/populace/content/ContentDesc.aspx?menu_id=12036
8. Energy Knowledge Bank of the Bureau of Energy, Ministry of Economic Affairs: https://km.twenergy.org.tw/energy/operating_more?id=8

Chapter 5

Impacts of Climate Change and Adaptation Measures

5.1 Climate change hazards

5.2 Impact of climate change

5.3 Adaptation measures and results

Chapter 5 Impacts of Climate Change and Adaptation Measures

Taiwan has high terrain, flashy streams, and frequent typhoons with strong winds and heavy rainfall, often causing floods and landslides. In the future, the occurrence of extreme weather due to climate change will increase, making Taiwan more vulnerable to threats. Therefore, how to respond to such an issue is an urgent task for Taiwan.

The assessment of the impact of climate change in Taiwan is based on the specifications of the IPCC Fifth Assessment Report (AR5), which defines the "risk" of climate change as a function of "hazard," "exposure," and "vulnerability." According to the IPCC definition, "hazard" represents a possible natural or man-made physical event or trend or physical impact; "exposure" represents the location and setting where human life, livelihoods, species or ecosystems, environmental services and resources, infrastructure, economy, social and cultural assets may be adversely affected; "vulnerability" represents the propensity or predisposition which is likely to be negatively affected. Vulnerability encompasses a variety of concepts, including sensitivity, susceptibility to hazards, lack of coping, and adaptive capacity.

Section 5.1 of this Chapter integrates observation and projection information and introduces the "hazards" of Taiwan when encountering climate change. Section 5.2 introduces the "risks" of Taiwan when encountering climate change. Section 5.3 introduces the policies and measures implemented in response to the climate change risks in Taiwan.

5.1 Climate change hazards

This Section utilizes the historical data of meteorological observation combined with the projection of future climate to describe the hazards of climate change in Taiwan. Regarding the meteorological observation, the historical data of meteorological observation collected by the Central Weather Bureau, MOTC (Ministry of Transportation and Communications,) was used. As to the projection of future climate, the emission scenario assumptions of the IPCC AR5 (IPCC Fifth Assessment Report) and the IPCC AR6 (IPCC Sixth Assessment Report) were comprehensively adopted, including 4 "Representative Concentration Pathways (RCPs) [3] " of greenhouse gases and 5 "Shared Socioeconomic Pathways (SSP) [4] .

5.1.1 Temperature

Looking back at Taiwan's historical temperature records, it is apparent that the temperature in Taiwan has continued to rise since 1900, and the rate of temperature rise shows an increasing trend. From 1900 to 1920, the temperature increased slowly. From 1920 to 1940, the rate of temperature rising was increased. From 1940 to 1970, the rate of temperature rising was decreased again. However, after 1980, a stage of rapid temperature increase was encountered, as shown in Figure 5.1.1-1.

[3] RCP8.5 (high GHG emissions), RCP6.0, (moderate-to-high global warming), RCP4.5 (moderate-to-low global warming), RCP2.6 (slow down of global warming)

[4] SSP1-1.9 (very low GHG emissions scenario), SSP1.-2.6 (low GHG emissions scenario), SSP2-4.5 (moderate GHG emissions scenario), SSP3-7.0 (moderate-to-high GHG emissions scenario), SSP5-8.5 (very high GHG emissions scenario)

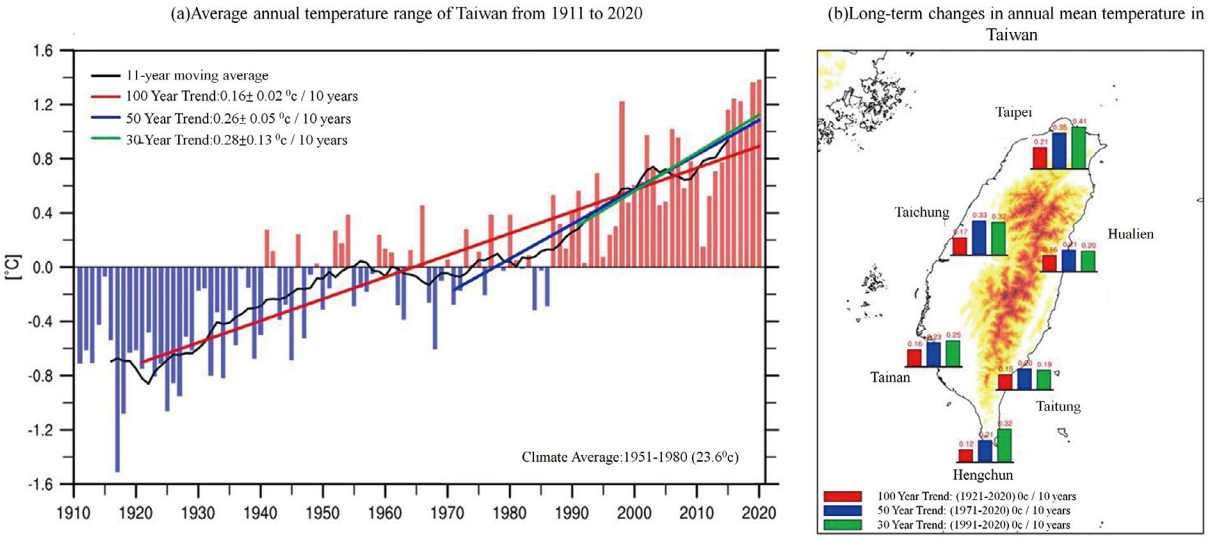

Figure 5.1.1-1: Observation of temperature in Taiwan from 1911 to 2020

Source: Ministry of Science and Technology, "Scientific Highlights of the IPCC Sixth Assessment Report (AR6) on Climate Change and the Update Report on Climate Change Review and Analysis in Taiwan," 2021.

A comparison of the average temperature in the summer half year and the winter half year over the years further shows that the temperature in the summer half year has risen steadily since 1900, while the temperature in the winter half year has varied with time, as shown in Figure 5.1.1-2.

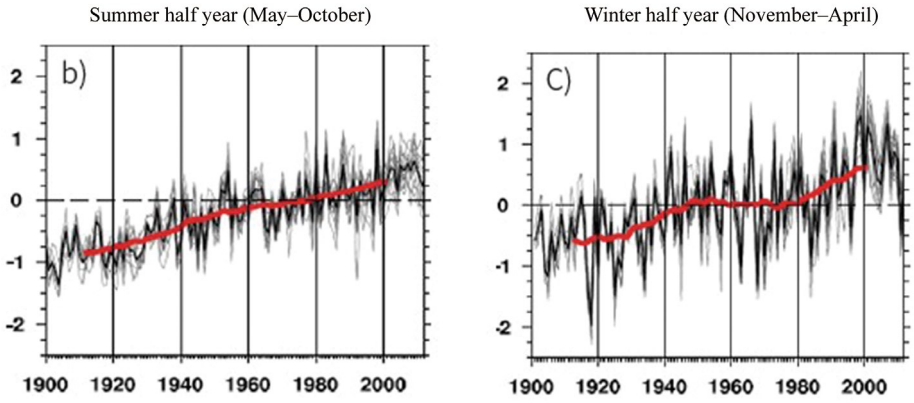

Figure 5.1.1-2: Observation of temperature in Taiwan from 1911 to 2017

Source: Taiwan Climate Change Projection Information and Adaptation Knowledge Platform project, "The Past and Future of Taiwan's Climate: Taiwan Climate Change Scientific Report 2017 - Highlights of Physical Phenomena and Mechanisms," 2018.

Temperature changes affect the distribution of the four seasons. In the early 21st century, the length of summer increased to about 120-150 days, and the length of winter was shortened to about 70 days. In recent years, the length of winter was further shortened to about 20-40 days. The daily temperature difference also changed. From 1907 to 2017, the daily maximum temperature increased by 0.8°C, and the daily minimum temperature increased by 1.7°C, as shown in Table 5.1.1-1. In terms of the Diurnal Temperature Range (DTR), which is the difference between the daily maximum and minimum temperature, DTR increased by 0.7°C from 1900 to the 1930s, and then began to decrease slowly, decreasing by 1°C in 2012. Overall, the Diurnal Temperature Range decreased by 0.3°C.

Table 5.1.1-1: Average temperature increase in Taiwan from 1907 to 2017

	Average temperature	Daily maximum temperature	Daily minimum temperature
Whole year	23.1°C (+1.3°C)	27°C(+0.8°C)	20.2°C (+1.7°C)
Summer half year	26.7°C (+1.3°C)	30.5°C (+0.9°C)	23.7°C (+1.8°C)
Winter half year	19.6°C (+1.2°C)	23.4°C (+0.9°C)	16.6°C (+1.7°C)

Source: Taiwan Climate Change Projection Information and Adaptation Knowledge Platform project, "The Past and Future of Taiwan's Climate: Taiwan Climate Change Scientific Report 2017 - Highlights of Physical Phenomena and Mechanisms," 2018.

Generally, the annual average temperature in Taiwan has increased by about 1.6°C in the past 110 years (1911-2020), and the temperature increase has accelerated in the past 50 and 30 years; it is projected that the temperature in various places will continue to rise in the future. Under the worst-case scenario of global warming (SSP5-8.5), the average annual temperature in the mid-21st century and the end of the century may increase by more than 1.8°C and 3.4°C, respectively, while that under the best-case mitigation scenario of global warming (SSP1-2.6) may increase by 1.3°C and 1.4°C, respectively.

In predicting future trends, the average temperature from 1985 to 2014 was used as the baseline to predict the trend of temperature change in Taiwan by 2100. Under the IPCC AR6 worst-case scenario of global warming (SSP5-8.5), the average annual temperature in the mid-21st century and the end of the century may rise by more than 1.8 °C and 3.4 °C, respectively, and the higher the concentration of greenhouse gases, the greater the temperature rise. In terms of temperature distribution, with the increase of time and under the four greenhouse gas concentration scenarios, the degree of temperature rise will vary depending on geographical locations. The temperature rise in the northern region of Taiwan will be more significant than that in other regions, as shown in Figure 5.1.1-3. The length of summer in the future will increase from approximately 130 days at present to 155-210 days, and the length of winter will decrease from approximately 70 days at present to 0-50 days. Under the worst-case scenario, the change is obvious, while the change is relatively moderate under the best-case mitigation scenario as shown in Figure 5.1.1-4.

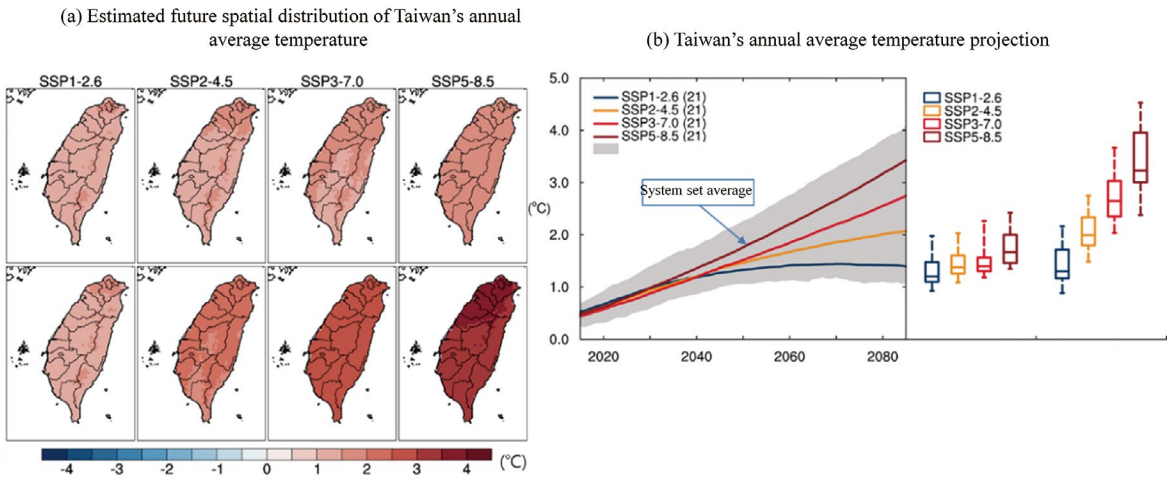

Figure 5.1.1-3: Distribution map of predicted trends of future temperature models in Taiwan

Source: Ministry of Science and Technology, "Scientific Highlights of the IPCC Sixth Assessment Report (AR6) on Climate Change and the Update Report on Climate Change Review and Analysis in Taiwan," 2021.

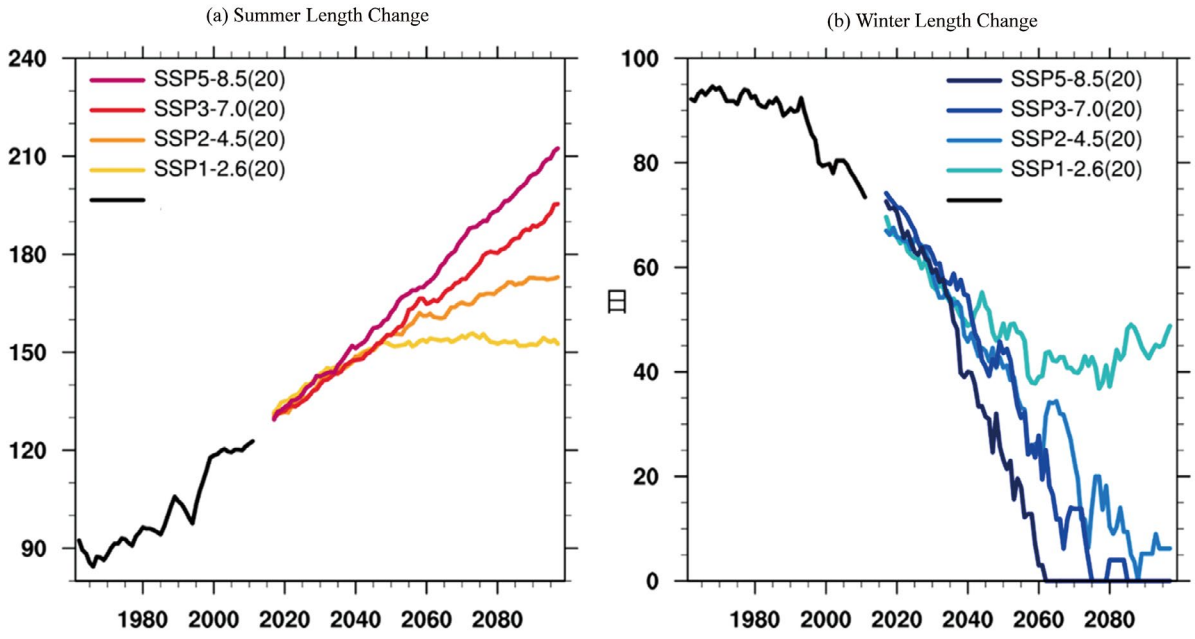

Figure 5.1.1-4: Projection of future seasonal length in Taiwan

Source: Ministry of Science and Technology, "Scientific Highlights of the IPCC Sixth Assessment Report (AR6) on Climate Change and the Update Report on Climate Change Review and Analysis in Taiwan," 2021.

5.1.2 Sea level

The global and Taiwan's average sea level have risen in the past few decades. The global average sea level has risen by 0.19 meters in the past 100 years. Meanwhile, the sea level in the surrounding waters of Taiwan has risen at a rate of 3.4 millimeters (mm) per year in the past 20 years.

Looking back at the historical sea level records, the waters around Taiwan (Northwest Pacific Ocean) have shown a rising trend since 1961, and the rate has increased rapidly in the past 20 years. From 1961 to 2003, the sea level in adjacent waters rose by an average of 2.4 mm per year. In the recent 20-year period between 1994 and 2013, the rate of sea level rise increased to 3.4 mm per year.

According to the WGI Interactive Atlas published by the IPCC AR6 and under the worst-case scenario (SSP5-8.5) of the East Asia region where Taiwan is located, the median sea level rise for the recent period (2021-2040) is 0.1 m (P5-P95 percentile is 0.0-0.2 m), for the mid-century (2041-2060) is 0.3 m (P5-P95 percentile is 0.1-0.5 m), and for the end of the century (2081-2100) is 0.7 m (P5-P95 percentile is 0.3-1.2 m). In the future, Taiwan will continue to strengthen the capacity building in sea level projection.

5.1.3 Rainfall

Taiwan's rainfall exhibits chronological and seasonal differences. Although the trend of rainfall changes in the past 100 years is not obvious, it can be seen from related rainfall indicators that the difference between dry and wet seasons has become more and more pronounced (Summer and autumn are also called wet seasons, which are characterized by the plum rain and typhoons that bring abundant rainfall to Taiwan. Winter and spring, on the other hand, are also called dry seasons; except for the northern region of Taiwan, there is no significant rainfall). Under the worst-case scenario (RCP8.5), Taiwan's wet season rainfall will increase by the end of the 21st century, especially in the central region. In contrast, the dry season rainfall will decrease, especially in the southern region.

Looking back at Taiwan's historical rainfall records, in terms of annual total precipitation and precipitation index, there has been no significant long-term change in the past 100 years, as shown in Figure 5.1.3-1ab. However, after the 1960s,

the number of drier years increased significantly compared with the previous half century (see Figure 5.1.3-1ab for details). The maximum one-day heavy rain intensity trend did not change significantly; from 1990 to 2015, the annual maximum one-day heavy rain intensity increased significantly, while that in the past three years (2018-2020) decreased significantly (see Figure 5.1.3-1cd for details).

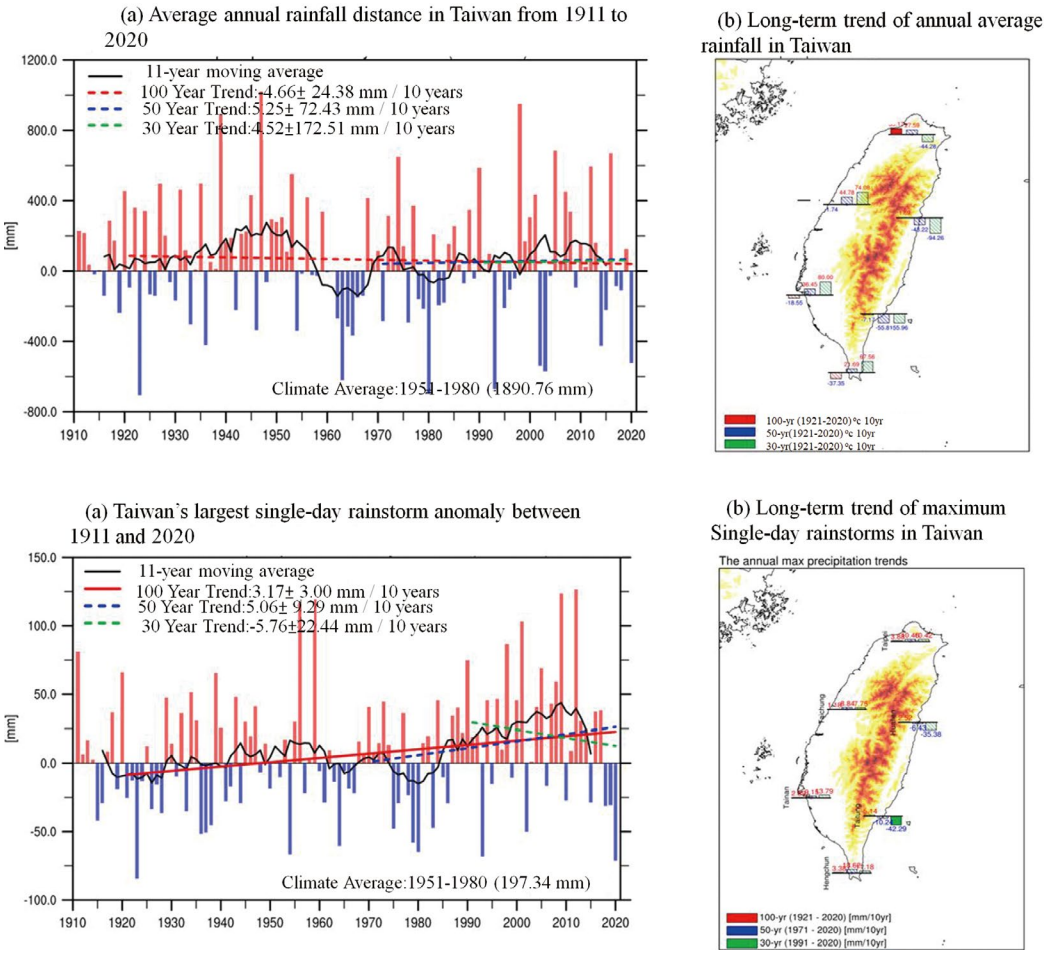

Figure 5.1.3-1: Observation of rainfall in Taiwan from 1911 to 2020

Note: a) annual average rainfall; b) annual average rainfall variation by region; c) heavy rain intensity; d) heavy rain intensity by region

Source: Ministry of Science and Technology, "Scientific Highlights of the IPCC Sixth Assessment Report (AR6) on Climate Change and the Update Report on Climate Change Review and Analysis in Taiwan," 2021.

For the trend prediction of the best-case mitigation scenario and the worst-case scenario of AR6 in the future, by the mid-21st century, the annual total rainfall is expected to increase by 12% and 15%, respectively, the annual maximum one-day heavy rain intensity is expected to increase by 15.7% and 20%, respectively, and the annual maximum consecutive days without rainfall is expected to increase by 1.8% and 5.5%, respectively; by the end of the century, the annual total rainfall is expected to increase by 16% and 31%, respectively, the annual maximum one-day heavy rain intensity is expected to increase by 15.3% and 41.3%, respectively, and the annual maximum consecutive days without rainfall is expected to increase by 0.4% to 12.4%, respectively, as shown in Figure 5.1.3-2.

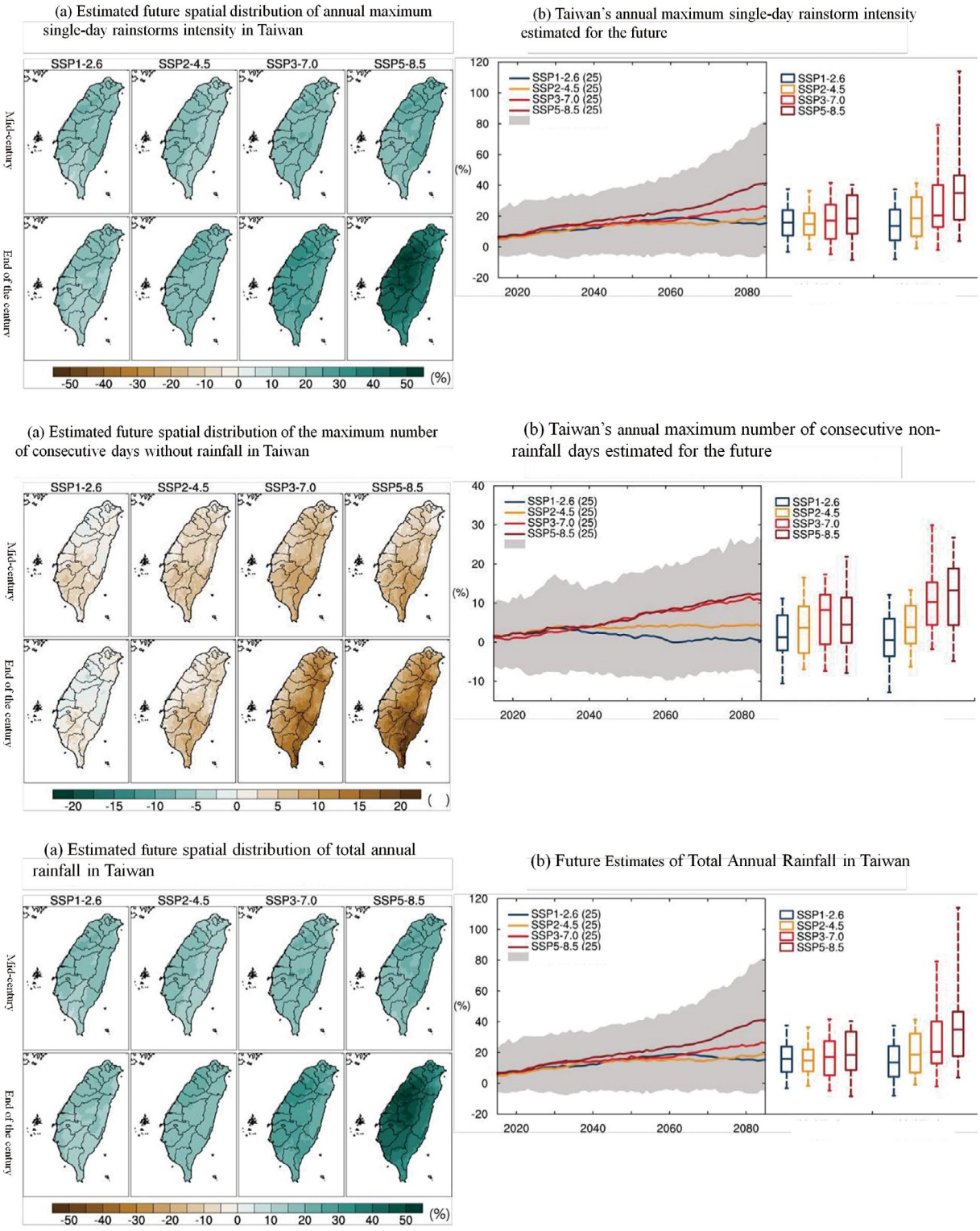

Figure 5.1.3-2: Prediction of future rainfall trend in Taiwan

Source: Ministry of Science and Technology, "Scientific Highlights of the IPCC Sixth Assessment Report (AR6) on Climate Change and the Update Report on Climate Change Review and Analysis in Taiwan," 2021.

5.1.4 Typhoons and extreme weather

I. Typhoons

Looking back at Taiwan's historical typhoon records, the number of typhoons in Taiwan shows significant annual variations. However, the trend of increase in the number of typhoons over the years is not obvious, as shown in Figure 5.1.4-1.

For the trend prediction of the AR5 scenario in the future, by the mid-21st century, the number of typhoons affecting Taiwan is expected to decrease by 15%, the number of strong typhoons is expected to increase by 100%, and the rate of change in typhoon rainfall is expected to increase by 20%; by the end of the 21st century, the number of typhoons affecting Taiwan is expected to decrease by 55%, the number of strong typhoons is expected to increase by 50%, and the rate of change in typhoon rainfall is expected to increase by 35%.

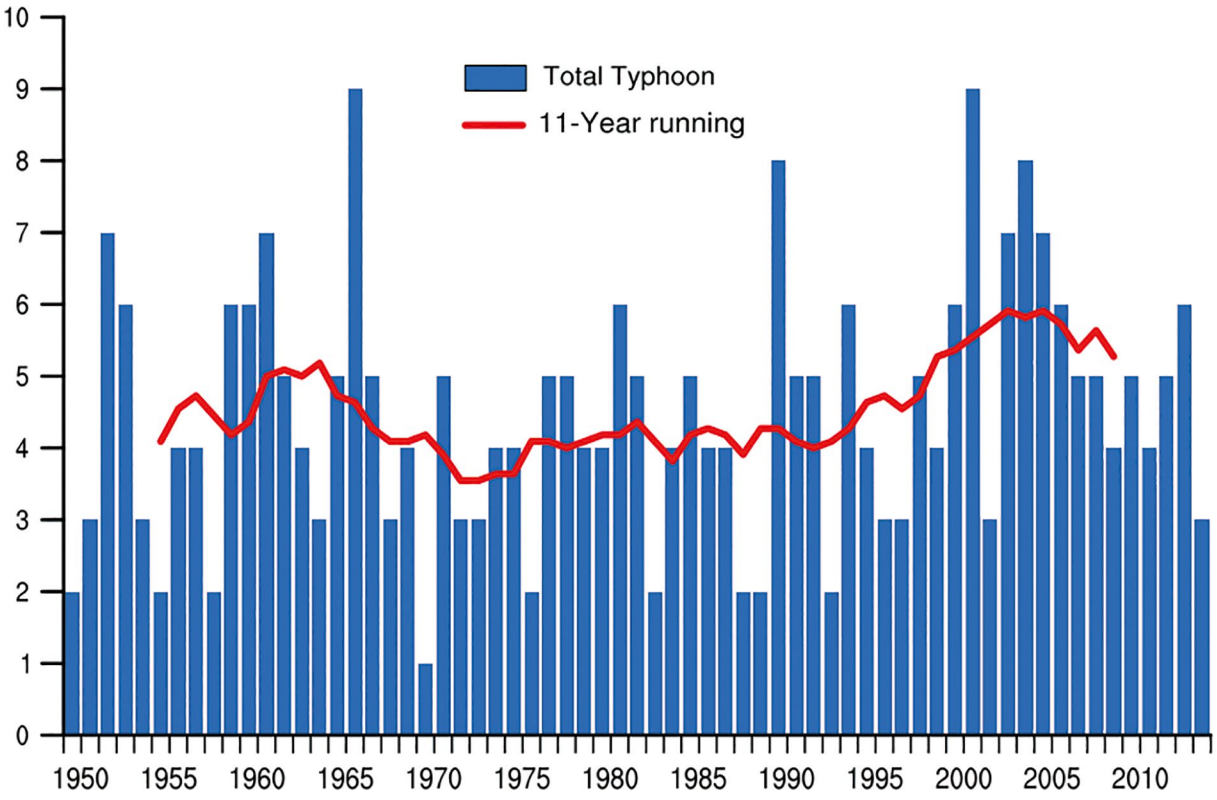

Figure 5.1.4-1: Number of typhoons in Taiwan from 1950 to 2014

Note: The red line represents the 11-year running, the X-axis represents the year, and the Y-axis represents the number of typhoons. Only the number of typhoons that are within 300 km from Taiwan's coastline and stayed for more than 12 hours (inclusive) are counted.

Source: Taiwan Climate Change Projection Information and Adaptation Knowledge Platform project, "The Past and Future of Taiwan's Climate: Taiwan Climate Change Scientific Report 2017 - Highlights of Physical Phenomena and Mechanisms," 2018.

II. Extremely high temperature

Over the past 50 years, the frequency and intensity of extremely high temperature in Taiwan have increased. In the future, under the worst-case scenario (RCP8.5), the number of days with extremely high temperature (over 95% percentile) in Taiwan may increase by more than 100 days per year.

Looking back at Taiwan's historical records on extremely high temperature , the number of days with extremely high temperature began to increase rapidly since 1970, as shown in Figure 5.1.4-2.

For future trend prediction, the number of days with extremely high temperature (temperature above 36°C) in Taiwan will increase. It is predicted that, by the mid-21st century, the number of days with extremely high temperatures of the best-case

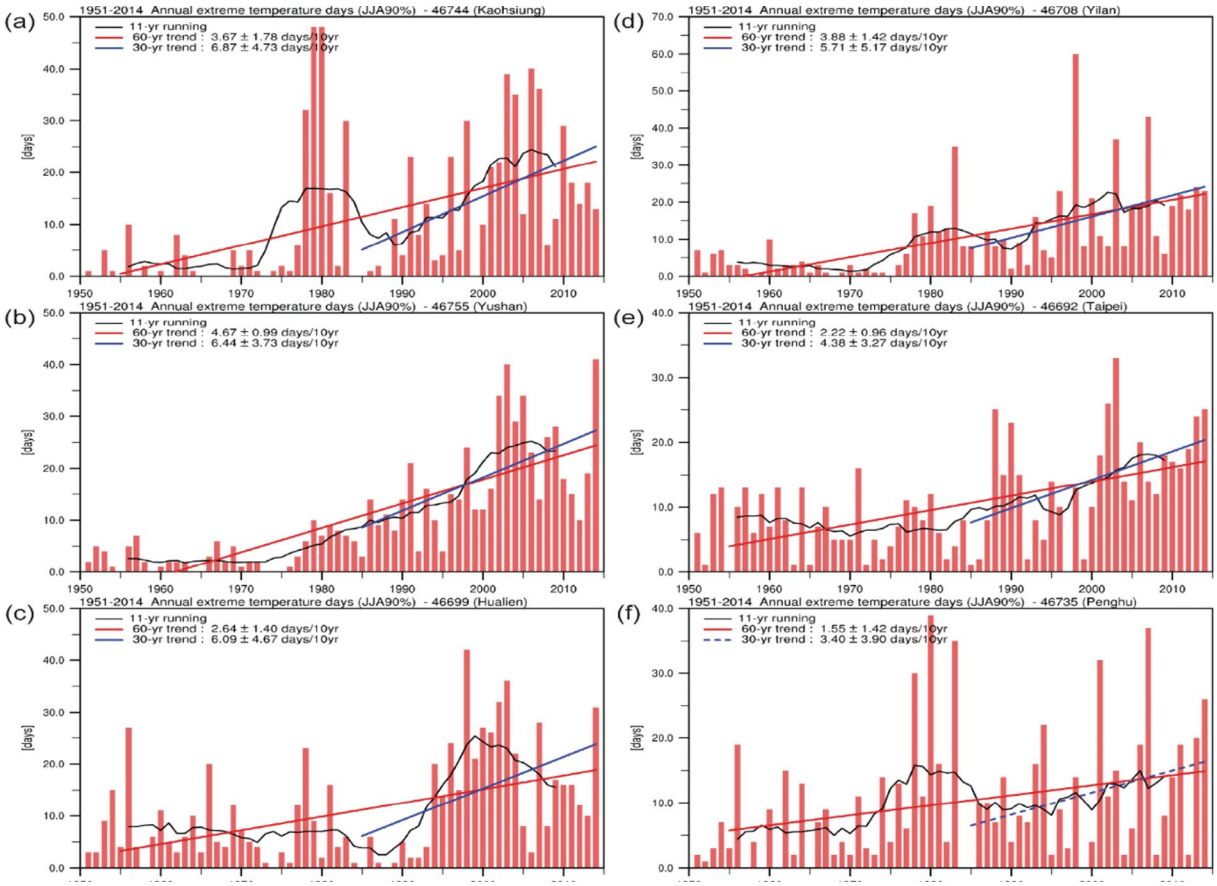

Figure 5.1.4-2: Number of days with extremely high temperature in Taiwan from 1951 to 2014

Note: Only the number of days with extremely high temperature observed by the six meteorological observation stations in Kaohsiung, Yushan, Yilan, Hualien, Taipei, and Penghu are included.

Source: Taiwan Climate Change Projection Information and Adaptation Knowledge Platform project, "The Past and Future of Taiwan's Climate: Taiwan Climate Change Scientific Report 2017 - Highlights of Physical Phenomena and Mechanisms," 2018.

mitigation scenario and the worst-case scenario of AR6 will increase by 6.8 and 8.5 days, respectively. By the end of the 21st century, it will increase by 6.6 and 48.1 days, respectively, among which the increase in urban areas is more significant than that in other areas, as shown in Figure 5.1.4-3.

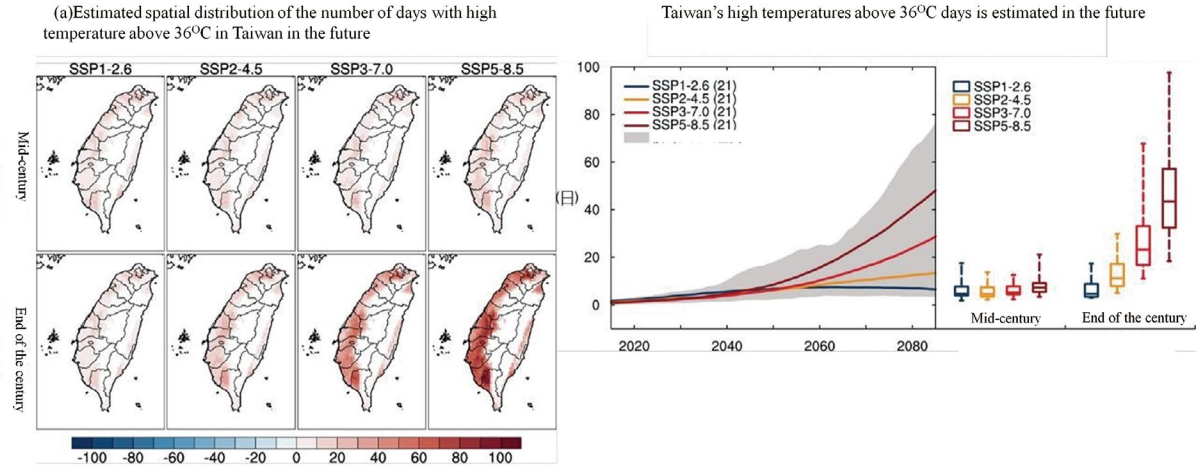

Figure 5.1.4-3: Prediction of extremely high temperature trend in Taiwan in the future

Source: Ministry of Science and Technology, "Scientific Highlights of the IPCC Sixth Assessment Report (AR6) on Climate Change and the Update Report on Climate Change Review and Analysis in Taiwan," 2021.

3. Heavy Precipitation

Looking back at Taiwan's historical rainfall records, the number of days with heavy precipitation has increased in the past 50 years, especially in mountainous areas (green line and light blue line as shown in Figure 5.1.1-4).

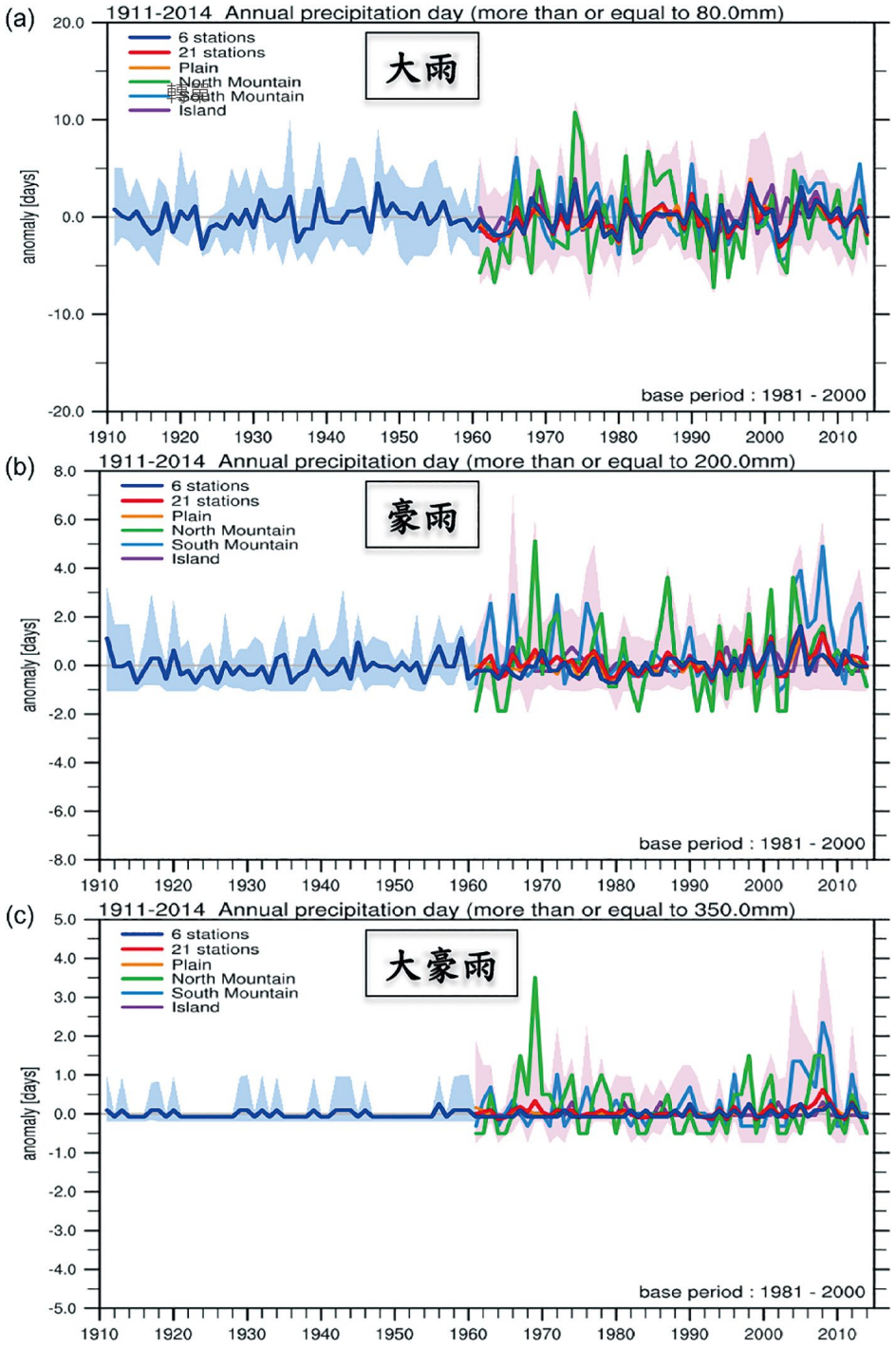

Figure 5.1.4-4: Number of days with heavy rain, extremely heavy rain and heavy precipitation in Taiwan from 1910 to 2013

Note: Heavy rain is defined as daily rainfall ≧ 80 mm, extremely heavy rain is defined as daily rainfall ≧ 200 mm, and torrential rain is defined as daily rainfall ≧ 350 mm. Figure 5.1.4-4 shows the anomaly of the number of days of heavy rain, extremely heavy rain and torrential rain minus the number of days in the base period (1961 to 1900) in Taiwan from 1910 to 2013.

Source: Taiwan Climate Change Projection Information and Adaptation Knowledge Platform project, "The Past and Future of Taiwan's Climate: Taiwan Climate Change Scientific Report 2017 - Highlights of Physical Phenomena and Mechanisms," 2017.

For the prediction of future trends, under the worst-case scenario (RCP8.5) of AR5, the number of days with extremely heavy rain in Taiwan in the 21st century shows an increasing trend. Comparing the changes in the four regions of northern, central, southern, and eastern Taiwan, the percentage of increase in all regions is higher than 70%, with the largest change in central Taiwan (an increase of 128.1%, as shown in Figure 5.1.4-5).

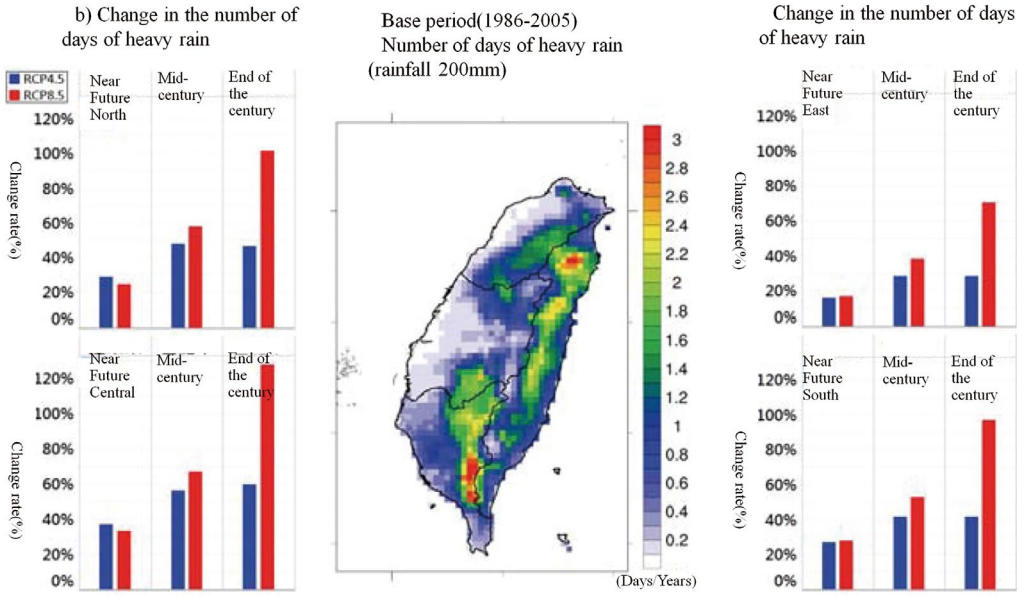

Figure 5.1.4-5: Number of days with extremely heavy rain in Taiwan from 1999 and 2099

Note: ECHAM5 and MRI are climate models developed in Germany and Japan, respectively.

Source: Taiwan Climate Change Projection Information and Adaptation Knowledge Platform project, "The Past and Future of Taiwan's Climate: Taiwan Climate Change Scientific Report 2017 - Highlights of Physical Phenomena and Mechanisms," 2018.

5.1.5 Models and methodologies

Currently, the data of the global climate model used in Taiwan are produced by climate centers and research institutes around the world. The research team of the Ministry of Science and Technology has established the AR4 and AR5 climate change projection database for Taiwan and has started to use the Coupled Model Inter-comparison Project Phase 6 (CMIP6) analyzed by the IPCC report in 2020 to provide the latest and complete climate change projection information. Different from the previous version of AR5, in addition to covering more climate model data, AR6 adopts the "Shared Social-economic Pathways (SSP)" for the setting of climate change scenarios (Figure 5.1.5-1), adding socioeconomic factors to the CMIP5 warming pathway, so that the needs of both mitigation and adaptation in scenario setting can be considered.

Since the spatial resolution of the original data of the global model (about 150~300 km) is too rough for Taiwan's application analysis, it is impossible to carry out effective localized climate change risk assessment and impact analysis. Currently, the research team of the Ministry of Science and Technology has improved the spatial resolution of the global climate model around Taiwan to 5 km through two downscaling methods.

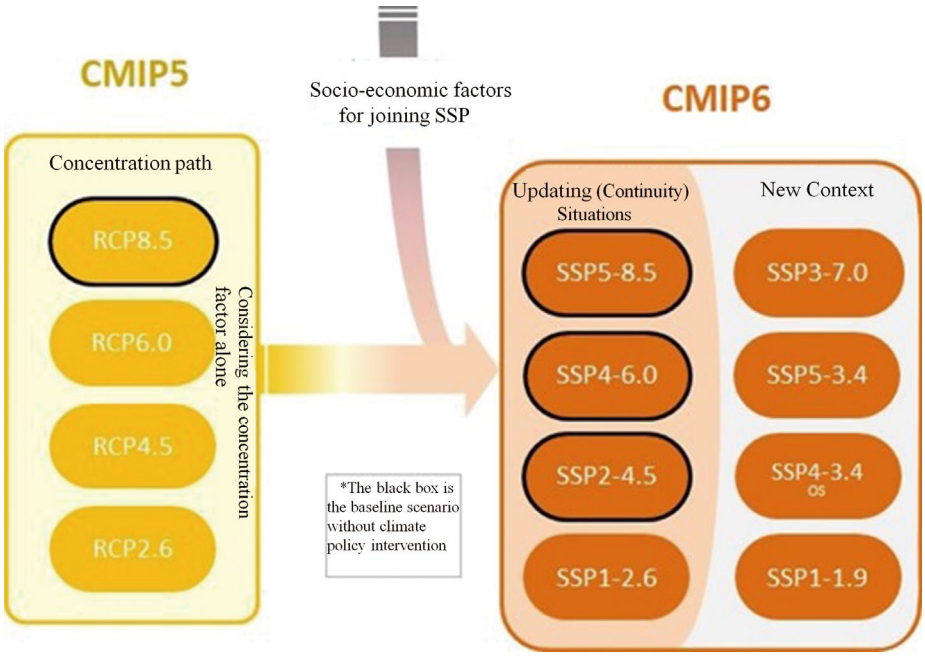

Figure 5.1.4-6: Illustration of CMIP6 Warming Scenario

Source: National Science and Technology Center for Disaster Reduction

I. Statistical downscaling

Statistical downscaling uses high-resolution observation grid data as the basis to correct and improve the resolution of the global model data, meeting the climate characteristics of Taiwan. Since its production speed is fast, applying multi-model data will help solve the uncertainty of future climate projection results, which is important for applying adaptation policies. However, this method is limited by the density of the original observation data, as well as the resolution of the original global model that cannot display severe weather systems, such as typhoons and plum rains, making it impossible to provide complete meteorological variables and simulation results.

II. Dynamical downscaling

For the impact assessment of extreme events under global warming scenarios, dynamical downscaling method of physical model is used, which can generate the required meteorological variables (such as wind field changes), hourly time-scale data, and extreme weather events (such as typhoons). This method can provide relevant scientific data for climate change risk assessment for high-impact typhoon-induced disasters such as flooding, slope, coastal area, etc.

5.2 Impact of climate change

Currently, the three types of hazards in Taiwan that are caused by extreme weather events and have more comprehensive studies are flooding, slope disaster, and drought. The major risk factor is rainfall; however, they are also affected by social and economic factors. Flooding and slope disasters mainly occur in the plum rain season (May and June) and during typhoons, while droughts mostly occur between spring and summer.

Under the scenario of global warming, the precipitation volume, as well as the frequency and intensity of extreme rainfall in the future in Taiwan, will increase, which will, in turn, increase the risk of river flooding, urban flooding, and landslides on slopes. The widening of the difference between wet and dry seasons will also increase the drought area.

The "Taiwan Climate Change Scientific Report 2017 - Impact and Adaptation Aspects" of the Ministry of Science and Technology reviewed journal articles in various fields, the studies conducted by the Ministry of Science and Technology, and the projects organized by various ministries and committees (or councils) to understand the risks and vulnerability faced by Taiwan under climate change. They are summarized by different fields and described as follows:

5.2.1 Terrestrial ecology

The temperature and sea level rise brought about by climate change will impact Taiwan's terrestrial ecosystem. In mountainous areas, the temperature rise has already affected the distribution of animals and plants. Taking Yushan National Park as an example, several species of birds originally inhabited at altitudes of 2,000 to 3,000 meters have begun extending to the alpine areas above 3,100 meters. A similar situation also occurs for mountain plants. Since 1906, a variety of plants that were originally distributed in medium-low and low altitudes gradually moved to high altitudes. The alpine plants originally dominating the high-altitude ecological space have faced additional competition, and they can't migrate to higher places. Current studies have pointed out that six alpine plants will face the crisis of extinction. In coastal areas, sea level rise will submerge some plant habitats. Taking the black-faced spoonbill as an example, if the sea level rises by two meters in the future and submerges part of the coastal wetlands in Tainan and Chiayi, the area for black-faced spoonbills to forage and rest will be greatly reduced.

5.2.2 Marine ecology

According to the IPCC AR5, in the future, the surface water temperature in the vicinity of Taiwan will be slightly higher than the global average. It is projected that in the future, the exchange of surface and bottom seawater will slow down, and the concentration of nutrients will decrease, which will affect the primary productivity of the ocean, and change the distribution as well as the life history of marine organisms. In addition, the increase in carbon dioxide concentration will also reduce the pH of the ocean from 8.2 before the industrial revolution to 7.8 in 2100, disturbing the physiological mechanism of aquatic organisms and affecting marine biodiversity.

5.2.3 Water resources

Although Taiwan currently has abundant rainfall, the distribution of rainfall in terms of time and space is quite uneven. Moreover, the water demand for domestic and industrial use in various counties and cities continues to grow.

Under the scenario of global warming, streamflow across Taiwan will decrease in the dry season. In the wet season, rainfall duration will be shortened in the northern and eastern Taiwan, and the frequency of extreme rainfall events will increase, which will also increase the turbidity of water resources and increase reservoir siltation. Such problems are detrimental to the allocation of water resources. It is predicted that in the future, except for the northern Taiwan and the eastern Taiwan that relies on groundwater, many counties and cities will experience water supply shortage in the dry season, and the water for agricultural use will be the first to suffer the impact of water rationing.

5.2.4 Food production and food securit

Climate change has affected crops, fisheries, and livestock production, causing impact on Taiwan's food security.

In terms of agriculture, the structure of Taiwan's current crop production is unbalanced. Rice is overproduced, while corn, wheat, soybeans, and sucrose are heavily dependent on imports. In addition, Taiwanese people's consumption is increasingly reliant on imported food, resulting in a severe trade deficit. Under climate change, crop growth is affected by climate. Extreme weather events may damage crops and reduce production, increasing global food prices, affecting food imports and weakening food supply chains. For this reason, stabilizing the food supply chain and improving self-sufficiency have become urgent tasks for Taiwan.

Regarding fishery, Taiwan's current offshore fisheries are polluted by industrial and commercial development. Furthermore, the limited area easily results in overfishing. Aquaculture is also faced with problems such as water pollution and excessive groundwater pumping, gradually reducing the available areas. Under climate change, phenomena such as seawater warming, acidification, and abnormal water temperature may change fisheries and fish migration paths, increasing the difficulty in carrying out fishing operations. Aquaculture, on the other hand, is faced with the problem of increased landslide disasters, damaging the water quality and water sources of aquaculture, and rising sea levels to reduce the area of aquaculture, thereby lowering production.

In terms of animal husbandry, Taiwan is highly dependent on imported feed. Under climate change, global grain prices may rise, which will greatly increase the operating costs of related businesses or force livestock farmers to use inferior feeds, thereby reducing the resistance of livestock against diseases as well as the quality of related products.

5.2.5 Human health

The health effects of climate change can be classified into level-1, level-2, and level-3 health hazards. Level-1 health hazard refers to the direct harm caused by climate change disasters to the human body, such as the injuries or deaths caused by heatwaves and floods. Level-2 health hazard refers to the increase and change of the distribution of infectious diseases caused by climate change in epidemiology, such as the spread of insect-borne diseases caused by global warming or respiratory diseases caused by the increase in the number of allergens. Level-3 health hazard refers to large and long-term impact, including climate refugees, famine, and mental illness.

In terms of level-1 health hazard (non-communicable disease), extremely high temperature and low temperature are known to be risk factors for kidney disease, cardiovascular disease (such as hypertension), and chronic disease (such as diabetes). Many studies have shown the correlation between temperature and the number of hospital visits and mortality due to the above diseases in Taiwan.

In terms of level-2 health hazard (communicable disease), climate change will likely prolong the occurrence of infectious diseases, thereby increasing the risk of human infection. For example, global warming causes the spread of mosquitoes or other vectors, changing the transmission pattern of dengue fever, chikungunya fever, malaria, and other diseases. Extreme rainfall will affect microbial reproduction and infection pathways, increasing the chance of human exposure to pathogens.

5.2.6 Economy and society

Economic and social development depends on the stability of life-supporting infrastructure. The increase in the frequency of extreme weather events caused by climate change will impact the life-supporting infrastructure in hillside areas, altering the stability of water supply, electricity, and transportation and affecting industrial operations and livelihood.

In agriculture, stock farming, and fisheries, as described in Section 5.2.4 of this Chapter, climate change will impact supply chain security, reduce yields or increase costs, thereby reducing competitiveness.

In the manufacturing sector, in addition to direct damage to factories caused by extreme weather, climate change may also bring about losses due to interruptions in water, electricity, transportation, and raw material supply.

As for the service sector, the impact of climate change is slow but far-reaching. Taking the insurance industry as an example, extreme weather events have significantly affected insurance rates, which in turn reduced the willingness of some insurance operators to underwrite. Climate change will also impact the tourism industry and the health of workers. In addition to having a direct impact on outdoor workers, it will also add a burden to Taiwan's medical system.

5.2.7 Urban and rural

As to urban areas, the impact of climate change on Taiwan will include the aspects of heat island effect, water resources, fire, health, and economy. In addition, cities have become one of the important subjects of climate action internationally. It is required to strengthen the existing urban planning mechanisms and incorporate climate change into urban infrastructure planning as well as the subsequent policy development.

Regarding rural areas, Taiwan's rural area accounts for 87% of the total land area, which is faced with social problems such as serious out-migration, an aging population, low per capita income, as well as economic problems such as insufficient infrastructure and environmental pollution due to industrial development. This situation puts most rural areas in a state of "high vulnerability" and "low resilience." It is necessary to strengthen the existing rural infrastructure and guide the primary and secondary industries to cope with climate change in advance.

5.2.8 Coast and outlying islands

Currently, about 80% of the coast in Taiwan is facing an erosion crisis, which is due to the reduction of estuarine sand transport, the change of sediment transport routes, the groin effect of coastal structures, the change of wave climate characteristics, the rise of sea level and land subsidence. Most of them are related to area development and use by people. In addition, the coast is also polluted by domestic and industrial wastewater, marine debris, agricultural activities, power plants, and ships.

Under the scenario of global warming, the impacts of future climate change on Taiwan's coasts and outlying islands mainly include: changes in estuary sand sources due to rainfall patterns, typhoons affecting wave climate, rising sea levels that intensify storm surges caused by typhoons, escalating ocean temperature affecting interlayer convection and hypoxia, and the impact of the Siberian High on northern waves and sea temperatures.

5.3 Adaptation measures and results

In order to enhance Taiwan's ability to adapt to climate change, after passing the "Greenhouse Gas Reduction and Management Act" in 2015, the "National Climate Change Action Guideline" was proposed by the Environmental Protection Administration, Executive Yuan, serving as the overall framework for Taiwan to promote adaptation actions. In addition, Taiwan continues to revise relevant land-use laws and regulations and promote and review the "National Climate Change Adaptation Action Plan."

5.3.1 Implementation structure of adaptation plan

I. Regulations related to climate change adaptation

1. Greenhouse Gas Reduction and Management Act

Taiwan's climate change adaptation policy originated from the task force for "Planning the Implementation of Climate Change Adaptation Policy Guidelines and Actions Plans," established in 2009 by relevant ministries and councils (or committees), experts, scholars, NGOs, and industry representatives under the coordination of the Council for Economic Planning and Development (now renamed National Development Council), Executive Yuan. Project and review group meetings, regional symposiums, and national climate change conferences have been held successively to gather opinions from all walks of life and build consensus. On June 25, 2012, the Executive Yuan approved the "Adaptation Strategy to Climate Change in Taiwan." With reference to the actions of various countries in the world and considering the particularity and historical experience of Taiwan's environment, eight areas of adaptation were selected to formulate relevant strategies and implement the promotion mechanisms as well as the supporting measures (as shown in Figure 5.3.1-1). Subsequently, approved by the Executive Yuan on May 22, 2014, the "National Climate Change Adaptation Action Plan (2013-2017)" is jointly implemented by various ministries and councils (or committees).

The Greenhouse Gas Reduction and Management Act of Taiwan was promulgated and implemented by the Presidential Order on July 1, 2015. Subsequently, the "National Climate Change Action Guideline" was formulated according to the law, reaffirming the importance of adaptation in 8 areas and proposing coping strategies. The "Adaptation Strategy to Climate Change in Taiwan" and the "National Climate Change Action Guideline" jointly form the guiding principles of Taiwan's adaptation policy.

2. Spatial Planning Act

To cope with climate change, ensure national security, conserve the natural environment and cultural assets, promote the reasonable allocation of resources and industries, strengthen the management mechanism for land consolidation, restore environmentally sensitive areas and damaged lands, and pursue sustainable development for the country, the government actively promotes the "Spatial Planning Act." The main contents of the "Spatial Planning Act" include establishing a spatial planning system to confirm the priorities of spatial planning, demarcating the functional zones of national lands, establishing a permit system, establishing an information disclosure mechanism, incorporating public participation and

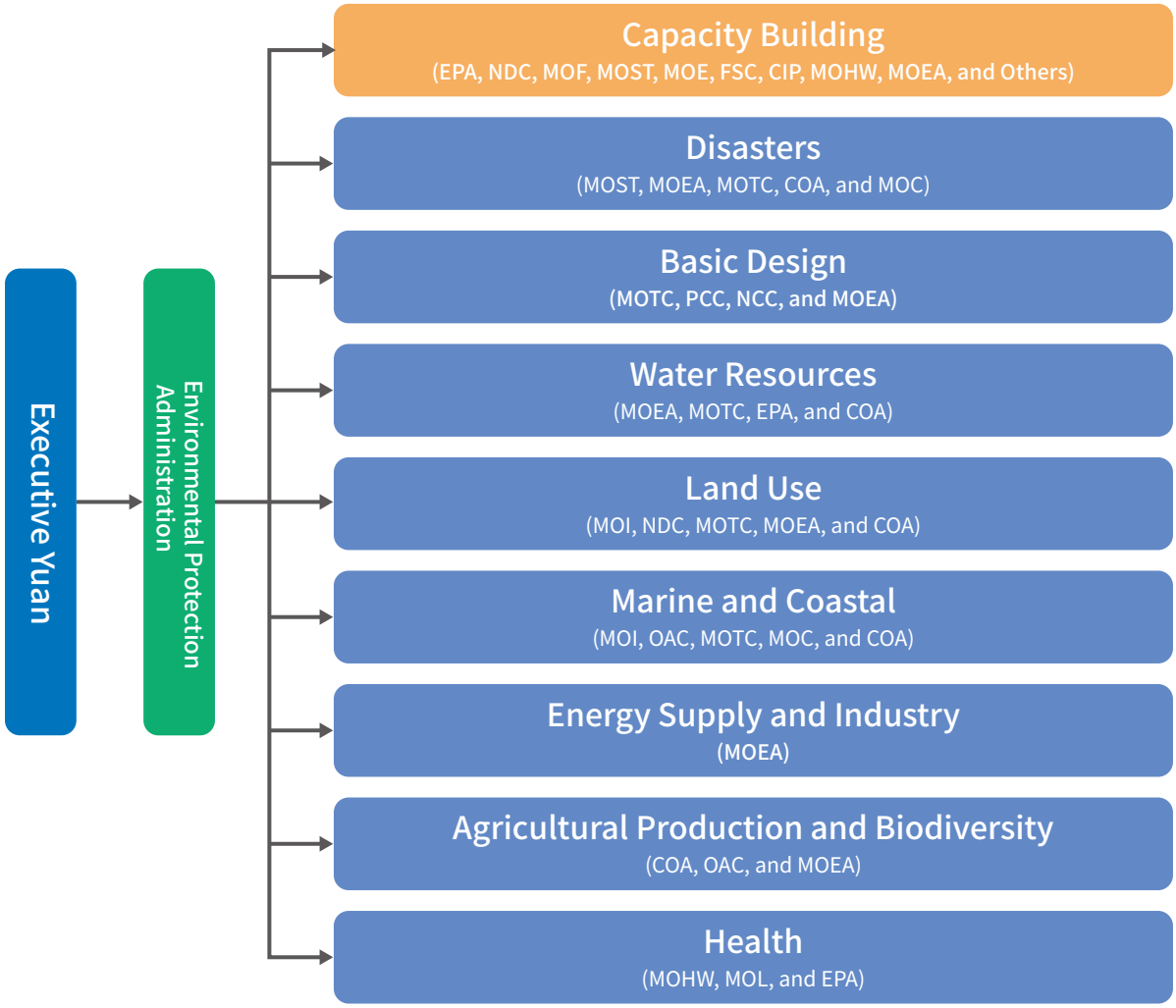

Figure 5.3.1-1: Division of work for National Climate Change Adoption Action Plan in Taiwan

Source: National Climate Change Adaptation Action Plan (2018-2022) (approved version).

supervision, implementing land restoration work, promoting environmentally sustainable development, protecting the rights of the public, and formulating a compensation and relief mechanism.

The Legislative Yuan passed the third reading of the latest draft amendment to the "Spatial Planning Act" on April 17, 2020. After the passing, it would help the central and local competent authorities to formulate and review the plan professionally and rigorously and fully implement information disclosure and public participation, jointly pursuing sustainable development for the country.

3. Coastal Zone Management Act

Taiwan is surrounded by sea, with a coastline of about 1,566 km and a vast area of coastal land. In recent years, with the rapid growth of society, economy, and population, coastal areas have become a new space that is indispensable in Taiwan's territorial development. However, land use in coastal areas is comprehensive and irreversible. In order to maintain natural coastal resources, the preservation, protection, and development of coastal areas must be carried out with correct judgment and a comprehensive perspective so that a balance between the three can be achieved.

To maintain natural systems, ensure zero loss of natural coasts, respond to climate change, prevent coastal disasters and environmental damage, protect and restore coastal resources, implement integrated

coastal management, and promote sustainable development of coastal areas, the "Coastal Zone Management Act" was announced and implemented in February 2015. Through the "Overall Coastal Management Plan," the guiding principles for the overall utilization of the coastal area are specified to guide and integrate the management of the coastal area and assign the location of coastal preservation and protection, as well as the agencies and deadlines for the formulation of the plan. Subsequently, according to the "Coastal Conservation Plan" and "Coastal Protection Plan," protection of natural resources and prevention of disasters will be actively carried out. In addition, guidance is provided to establish a review and permit system for the development and construction of coastal areas, further controlling the exclusive use of coastal waters and the construction of artificial facilities to ensure public access and public use.

4. Wetland Conservation Act

To ensure the natural flood retention function of wetlands, maintain biodiversity, promote ecological conservation and smart-use of wetlands, ensure zero net loss of important wetlands, and strengthen the interaction between wetlands and communities, the government of Taiwan announced the "Wetland Conservation Act" in July 2013, which came into force in February 2015.

The "Wetland Conservation Act" takes "smart-use" as the core spirit. Important wetlands are scattered throughout Taiwan. According to the characteristics of various wetlands, a conservation and utilization plan is formulated based on local conditions for substantive management, taking into consideration the use of the public. As a result, a balance between people's rights, local development, and environmental conservation can be achieved.

5. Water Act

"Water Act" is the basis for Taiwan to carry out the administration and development of water works, ensuring the supply and demand of water resources. Due to climate change, extreme rainfall in Taiwan is becoming more and more frequent. Furthermore, owing to high urbanization and substantial land development in the middle and upper reaches of river basins, the risk of flooding is increasing. In response to the above-mentioned impact, the Legislative Yuan passed the amendment of the "Water Act" after the third reading in May 2018 and promulgated the amendment in June 2018, adding a "special chapter on runoff sharing and outflow control," which requires land and building developers to jointly share the responsibility of flood retention and water storage in order to improve the overall flood resistance of the land.

5.3.2 Implementation results of adaptation plan

According to the "National Climate Change Action Guideline," the relevant central authorities continued to implement the adaptation action plans and related work in the eight major areas. The "National Climate Change Adaptation Action Plan (2018-2022)" was formulated by considering the implementation results of the "National Climate Change Adaptation Action Plan (2013-2017)."

The vision of the "National Climate Change Adaptation Action Plan (2018-2022)" is to "develop strategies to address climate change, improve adaptation capacity, strengthen resilience, and reduce vulnerability brought about by climate change impact to ensure sustainable development for the countries," which is divided into two parts: "climate change adaptation capacity building" and "adaptation actions in various fields." The "climate change adaptation capacity building" focuses on the continuous improvement of the foundation of climate change adaptation, while the "action plans in various fields" is divided into eight areas with a total of 71 projects.

I. Implementation results of "climate change adaptation capacity building"

The "Overall Adaptation Plan" includes a total of seven strategies, and the implementation results are as follows:

1. Promoting regulation and policy transformation

The adaptation strategy to promote the transformation of regulations and policies is to review existing regulations and policies and incorporate climate change factors to facilitate the implementation of climate change adaptation work.

Since 2020, Taiwan has begun to formulate the amendment of the "Greenhouse Gas Reduction and Management Act," adjust the climate governance framework of Taiwan based on past experience, and follow the global adaptation trend in order to strengthen administrative control,

complete economic incentives, and determine the responsibilities of various ministries and councils (or committees). In the same year, the "Agricultural Insurance Act" was passed to protect farmers from the losses caused by extreme weather events, which has laid the foundation for the government of Taiwan to use financial instruments to handle climate change in the future.

In addition, in response to the latest development trends of environmental protection at home and abroad as well as key domestic issues, and in line with Taiwan's current environmental issues as well as the future environmental vision, the "National Environmental Protection Plan" was re-compiled. The short-, medium- and long-term response strategies and corresponding mechanisms for the future were proposed to improve the country's environmental protection work.

Regarding land governance, the "National Spatial Plan" was announced and implemented in 2018, serving as the top statutory plan for national land use and planning. It incorporates climate change adaptation strategies and national land disaster prevention strategies. In 2021, spatial plans of all municipalities or counties (cities) have been announced and implemented. Adaptation plans will be formulated for climate change impact issues and risk locations.

The "Integrated Operational Guidelines for Improving the Resilience of Land Flood Control" was approved for flood control in 2019. The "Water Act" was amended by adding runoff and outflow control to strengthen the land's capability to withstand flooding. In 2020, the "Regulations for Site Survey and Safety Assessment of Geologically Sensitive Areas" was further amended to improve the resilience of land for flood control. In addition, the first-level coastal protection plans of six counties and cities and the second-level coastal protection plans of three counties and cities were approved.

In response to the increase in the number of days with high temperature caused by climate change, which in turn increases the occurrence of thermal injuries, and to prevent thermal injuries caused by occupations and sports, the "Notes on Protecting the Safety and Rights of Participants in Road Running Events" and the "Occupational Safety and Health Education and Training Rules" have been updated.

2. Promoting fiscal and financial measures

In response to the need for climate change adaptation, it is necessary to promote fiscal soundness and green financial measures, use financial instruments to bring diverse financial resources, make the financial burden fair and effectively utilize public resources.

Starting from 2020, Taiwan has included the disasters caused by typhoons or floods on residential buildings into the existing residential insurance. Moreover, in response to the passing of the "Agricultural Insurance Act," the Taiwan Agricultural Insurance Fund was established.

The Financial Supervisory Commission collaborated with the Council of Agriculture, Executive Yuan, to assist farmers in transferring climate risks, and has encouraged insurance companies to develop approximately 21 types of commercial agricultural insurance, including insurances for agricultural products, fishery products, poultry, and facilities, providing insurance for farmers and fishermen. As of June 2021, the number of insurance companies involved in undertaking the insurance business of domestic offshore wind power projects was about 13. To encourage insurance companies to develop green insurance, the authority has issued an order to simplify the review process for applying for long-term customized credit insurance. As of the end of June 2021, a total of 65 green bonds have been issued, with a total issued amount of approximately NT$172.2 billion. On June 30, 2020, a revision of the "Green Bond Operation Guidelines" was approved by the Taipei Exchange to add Islamic fixed-income securities into the scope of green bonds, providing multiple financing channels, and guiding funds to be invested in environmentally friendly applications. Moreover, to assist the financial industry in conducting appropriate risk assessment and control, the quality of credit operation and the capability to undertake green energy financing were improved, and professional research, as well as trainings conducted by the Taiwan Academy of Banking and Finance continued.

The government is also developing other fiscal and financial instruments related to climate change. In the future, it will continue to explore the possibility of integrating the existing fiscal and financial regulations during the revision of the "Greenhouse Gas Reduction and Management Act."

3. Completing scientific research, information and knowledge

Taiwan continues to take into account the development and trends of scientific research at home and abroad, promote the localization of climate change projection information, and strengthen the link between scientific research and policy. Currently, the "Taiwan Climate Change Projection Information and Adaptation Knowledge Platform project" has launched the third-generation climate change integrated service platform, and the research results promoted by the Ministry of Science and Technology over the years have been integrated into the platform, serving as references for the public as well as various ministries and councils (or committees).

Research on climate impact and adaptation strategies relies on various units of Taiwan at all levels to collect the impact of climate on the implementation of existing policies and develop countermeasures in advance while carrying out existing operations.

Taking into account the national development direction, social needs, and regional balanced development, the authority formulated science and technology policies to promote the development of relevant research. According to the "Fundamental Science and Technology Act," the Ministry of Science and Technology must propose a national science and technology development plan every four years. Based on the plan from 2014 to 2021, national marine weather, hydrology, ecology, and coastal land change monitoring network will be built in the future to enhance the national marine adaptation strategy and disaster response capability. It includes a comprehensive and real-time national marine hydrology, ecology, and land monitoring network to carry out fundamental and long-term studies, helping the sea area of Taiwan with scientific data and technology to engage in the development of smart agriculture (fishing) industry, renewable energy, marine adaptation strategies, and homeland security, thereby cultivating national disaster response capability to cope with the intensified challenges created by climate change. As to technology and implementation, various innovative waste treatment technologies will be developed through the government-industry-university-institute collaborations. Various "optimal and feasible control technologies" will be developed, and management methods as well as standards for bringing waste into the cycle will be established to improve the efficiency of resource use.

In terms of infrastructure, the Bureau of Energy, Ministry of Economic Affairs has established the "Risk Assessment Criteria for Energy Facilities" in accordance with the "Taiwan Integrated Research Program on Climate Change Adaptation Technology (TaiCCAT)." In 2019, the Ministry of Transportation and Communications completed the "Provincial Highway Improvement Plan – Strengthening the Prevention and Avoidance of Highway Disasters" and the "Six-Year Plan for Improving Railway Safety - Slope Full Life Cycle Maintenance and Management (technical services based on the entrustment system)," responding in advance the possible impact of the increased frequency of torrential rain and landslides on energy and transportation facilities.

In order to respond to the increased frequency of torrential rain in the future and extend the preparation time for disaster prevention and relief measures, the Water Resources Agency, Ministry of Economic Affairs has built a smart flood control network for 12 counties and cities. Based on modern transmission technology and with the improvement of front-end monitoring instruments, the smart flood control network is able to achieve the goal of disaster prevention and risk avoidance, reducing the losses during typhoons and torrential rain. In addition, to avoid environmental disasters caused by excessive groundwater pumping and to provide a reference for future joint use of surface and groundwater, a real-time automatic monitoring and management system for groundwater consumption has been gradually constructed to respond to the risk of land loss in advance due to sea level rise. In addition, an intelligent monitoring system is incorporated into the water supply system to reduce the loss of water from leakage. Big data analysis is adopted to intelligently manage and provide the optimal pressure for the time-sharing of the pipe network, responding in advance to any water supply risks when the frequency of droughts increases in the future.

In terms of public health, the Ministry of Health and Welfare has strengthened the current infectious disease notification system and included factors related to climate change in the database to facilitate future research needs. In addition, the National Health Research Institutes has completed a study on the impact of extreme temperatures

on the health of elderly people in Taiwan, and has prepared a risk map based on the results of the study.

Furthermore, the Council of Agriculture and the Ministry of Culture have also set up cultural and agricultural meteorological stations to accumulate data on the long-term impact of climate change on cultural assets and agriculture. The Endemic Species Research Institute is responsible for examining the impact of climate change on Taiwan's ecological diversity.

4. Implementing education, advocacy and talent cultivation

Phase II of the "National Climate Change Adaptation Action Plan" strengthens Taiwan's climate change education and talent cultivation. The main ways of promotion include incorporating climate change into the 12-Year Basic Education of Taiwan, providing subsidies for climate change teaching activities in universities, encouraging cross-disciplinary collaboration among university students across the country, developing students' climate action and learning-application connection capabilities through living laboratory, and encouraging climate change industry-university linkage to cultivate climate change professionals. Furthermore, "Climate Change Innovation and Implementation Competitions" were organized to stimulate students' creativity and capability in responding to climate change, and engaging in climate actions.

In addition to the education policies that the Ministry of Education is responsible for, relevant ministries and councils (or committees) also implement a series of advocacy measures according to their own business needs. For example, the Ministry of Health and Welfare uses questionnaires to understand the public's awareness of health risks that may be caused by climate change and converts them into effective early warnings, such as the prevention of low-temperature cold waves, the prevention of high-temperature thermal injury, and the thermal hazards publicized by the Ministry of Labor.

The Financial Supervisory Commission also continues to invite the Taiwan Academy of Banking and Finance and the Taipei Exchange to organize education and training courses or seminars, strengthen green finance talents' cultivation, and guide institutional investors and issuers to engage in the green bond market.

5. Developing emerging industry on climate change

This strategy combines the projects and measures currently implemented by the government with the industry to establish a public-private partnership, turning climate services into an emerging industry while completing public works. The results of the emerging industry development promotion plan are summarized as follows: To help farmers transfer climate risks, the government encourages insurance companies to develop commercial-based agricultural insurance; currently, there are more than 20 types of items.

(1) Implementing education, advocacy and talent cultivation

The " Industry Innovation Development and Promotion Plans for Smart Water Management" is promoted by the Ministry of Economic Affairs. It uses IoT technology to build a detection system that covers reservoirs, groundwater and irrigation water networks, forming a smart water resource monitoring system and providing businesses with the opportunity to integrate midstream and downstream supply chains into a complete service.

(2) Project of "Building a Disaster Prevention Service System for Marine Environment

The Ministry of Transportation and Communications has implemented the project of "Building a Disaster Prevention Service System for Marine Environment," which includes a series of technologies such as ocean heat content detection that can be applied to the early warning of marine weather. In the future, collaboration with offshore operation and marine engineering companies is expected to build a disaster prevention system.

(3) Project for Promoting Facility-based Agriculture

The project, promoted by the Council of Agriculture, Executive Yuan, guides farmers in building robust greenhouses. In addition to improving the resistance of crops to climate-related disasters, greenhouse agriculture can also effectively prevent pest attacks, reduce the use of pesticides, and integrate with automated agricultural facilities to transform into quality agriculture.

(4) Demonstration Project for Recycling and Reusing Discharged Water from Public Sewage Treatment Plants

The project is conducted by the Ministry of the Interior. A demonstration project has been completed at the Fengshanxi Sewage Treatment Plant in Kaohsiung City. A total of 4.5 tons of wastewater can be recycled daily. After treatment, the water is supplied to the Waterfront Industrial Area for reuse. It is hoped that in the future, such a successful experience can be extended to other industrial areas in Taiwan.

(5) LOHAS Meteorology APP – Health and Weather Service

"LOHAS Meteorology APP – Health and Weather Service" is the first health and weather early warning platform in Taiwan, jointly developed by the Health Promotion Administration, the Central Weather Bureau, and the Academia Sinica. The APP combines weather forecast data and health-related information and is the first to develop an early warning for heat injury levels and a threshold value. It also provides a reminder for demassified health education information, allowing the public to respond as quickly as possible.

6. Improving regional adaptive capacity

Following the achievements of the previous high-risk area adaptation plan, in addition to continuously conducting the "Northern Metropolitan Area Climate Change Adaptation Plan," the regional adaptation plans for the remaining six high-risk areas in Taiwan were implemented. By the end of 2020, preliminary results have been achieved in model prediction, disease control, infrastructure, and regional agriculture.

Regarding model prediction, the current climate change integrated service platform promoted by the Ministry of Science and Technology provides climate change data in different regions, facilitating the formulation and decision-making of climate change-related policies in various regions, counties, and cities. In terms of disease control, the Centers for Disease Control, Ministry of Health and Welfare, has established the monitoring mechanism for mosquitoes and other vectors of dengue fever in various regions, so as to grasp the distribution pattern of mosquitoes and other vectors in different climatic conditions and provide early warning. In terms of infrastructure, the Environmental Protection Administration and the Ministry of Transportation and Communications have completed the improvement projects for a number of main roads, waste incineration plants, and landfills, responding in advance to the possible climate impact in the future. In terms of regional agriculture, agricultural disaster reduction measures have been successively implemented in 6 high-risk areas, and the capacity of flood control and sewage drainage in coastal aquaculture areas has been strengthened.

7. Strengthening local adaptation measures

The primary goal of this strategy is to strengthen the communication and collaboration between local governments and central government (including various ministries and councils or committees). While integrating government policies at all levels, efforts were made to localize central government policies to meet local needs.

At the county and city government level, the Taiwan Climate Change Projection Information Platform (TCCIP) provides climate change data required for three local projects, including gridded observational data, statistical downscaling, etc. At the same time, the Council of Agriculture, Executive Yuan will also formulate spatial development plans for the agricultural sector of various counties and cities based on the assessment results of the vulnerability of farmland in the future to meet the needs of climate change adaptation. Preliminary results have been completed in Taichung City and Chiayi County.

At the community level, the Environmental Protection Administration, Executive Yuan has gradually implemented various adaptation measures locally. For example, the "Multifunctional Smart Rain Garden" project aims to build a green infrastructure based on IoT technology and use a soft landscape to achieve water retention and cooling effect. In the next two years, 14 demonstration sites will be built first in Taiwan. In addition, the Environmental Protection Administration, Executive Yuan has also promoted the action items of the "Low-carbon Sustainable Homeland Rating Promotion Project," encouraging the participating units in the three levels of villages, townships (towns, cities, districts) and municipalities, and counties (cities) to implement adaptation measures.

II. Implementation results of "Action Plans in Various Areas"

The "Action Plans in Various Areas" include 114 adaptation action plans in eight major areas, of which 63 are priority adaptation action plans. The implementation results are as follows:

1. Disaster

The adaptation strategy in the disaster area is the Phase II Disaster Action Plan, which includes building disaster risk assessment or knowledge, refining disaster risk management mechanisms, and constructing disaster early warning and response systems. There are five priority adaptation action plans in this area.

For the building of disaster risk assessment or knowledge, climate change risk maps were continuously constructed. The flood risk maps with four spatial scales, including township and district, a grid of 5 km, a grid of 40 m, and minimum population statistics area, were completed, and the application of the risk maps was discussed.

In promoting the refinement of disaster risk management mechanisms, through the construction and maintenance of the monitoring equipment for cultural asset preservation environment, cultural asset meteorological information is continuously improved to advance risk assessment research. In the construction of disaster early warning and response systems, through the establishment of the "high-speed rail slope safety early warning system," which is based on rainfall intensity, the possibility of slope disasters can be evaluated. In addition, the effectiveness of early warning and notification was improved: including the R&D and application of smart water condition early warning information services and optimization of the flood numerical calculation model to enhance the effectiveness of flood early warning and notification.

2. Life-supporting infrastructure

The main purpose of the Phase II Action Plan in the area of life-supporting infrastructure is to strengthen the capability in comprehensive risk assessment and improve the adaptive capacity of energy, water supply, public works, transportation, and telecommunications systems.

Currently, the Phase II Action Plan, in terms of the transportation system, has carried out an analysis and evaluation of high-risk transportation facilities. In addition, improvement of flood control capacity for Zhongsha Bridge, improvement of highway disaster prevention and avoidance, and long-term stability assessment for Taiwan Provincial Highway No.20 and Taiwan Provincial Highway No.29 were conducted. In terms of the water supply system, sensing and early warning systems were integrated continuously to assist local governments in managing water conditions and disasters. Moreover, a number of water supply facilities were completed to strengthen flood control capacity and backup water supply during droughts. In terms of public works, 52 construction inspection teams have been established across the country to review flood prevention and preparation operations. In terms of communication systems, the backup capability of base stations was improved. Furthermore, subsidies were provided to operators for the establishment of fixed-point and mobile disaster relief communication platforms to facilitate emergency response.

3. Water resources

The main purpose of the Phase II Action Plan in the area of water resources is to improve the resilience of the water supply system and to cope with the facility risk, system risk, and supply & demand risk brought about by the future growth of water resources and climate change in advance.

Currently, the Phase II Action Plan, in terms of strengthening water supply, has completed 18 new or improved infrastructure projects, increasing the daily water supply by 1.67 million tons, which is equivalent to 15% of the country's water sources. At the same time, the emergency water source for drought relief was strengthened. When a drought occurs, an additional 1.66 million tons of water can be added every day for emergencies. In the future, the management of catchment areas, reservoir dredging, pipeline leakage reduction, and water saving will continue to be improved.

4. Land use

The Phase II Action Plan in the area of land use focuses on land use planning to enhance the resilience of urban and rural areas and promote the sustainable use of land. Its three major action strategies are "strengthening the adaptive capacity of national land," "building a national ecological network," and "promoting the overall urban water control."

Currently, the Phase II Action Plan, in terms of strengthening the adaptive capacity of national land, has announced on April 30, 2021, the implementation

of the spatial plans for municipalities and counties (cities) according to the "Spatial Planning Act," which will be reviewed every five years. In addition, the assessment and adaptation of the vulnerability of agricultural land were promoted, serving as the reference for future action plans. In terms of building a national ecological network, sustainable development plans were promoted in national parks, and wetland conservation plans, as well as coastal management plans were added. In terms of promoting overall urban water control, national water environment improvement plans and urban renewal development plans were implemented. Furthermore, the implementation and review of the flood control, drainage, and flood retention capabilities of existing urban plans were strengthened, improving river drainage and sewer construction.

5. Coast and Ocean

The Phase II Action Plan in the area of coast and ocean promoted the monitoring, early warning, and assessment mechanism of marine resources. It includes three major action strategies: strengthening coastal adaptive capacity, strengthening monitoring and early warning mechanisms, and marine environmental conservation and survey.

Currently, the Phase II Action Plan, in terms of strengthening coastal adaptive capacity, is promoting research on resilient disaster prevention and climate change water environment risk assessment, conducting basic surveys on coastal resilience. It also carried out coastal protection plans and the overall planning for coastal land use to reduce the risk of disasters. In terms of strengthening the monitoring and early warning mechanisms, the Taiwan Marine and Meteorology Disaster Prevention Information Service System is currently being constructed. In the future, it is expected to provide disaster prevention and early warning services for units in fisheries, shipping, and disaster prevention. In terms of marine environment conservation and surveys, the quality of coastal waters is monitored on a quarterly basis to obtain long-term data. Surveys were conducted to obtain information on marine ecology and biodiversity along Taiwan's coastal areas (surveys for 67 reef ecosystems, three algal reef ecosystems, and a population of marine protected wildlife have been conducted). Through the establishment of long-term data and analysis, the results can serve as references for future policy development in response to climate change.

6. Energy supply and industry

The goal of the action plans in the area of energy supply is to ensure the security and quality of energy supply and to enhance the industry's climate risk awareness as well as opportunity identification capabilities. The goal of the action plans in the area of industry is to assist businesses in responding to the transition risks brought about by climate change.

The Phase II Action Plan, in the area of energy supply, has adjusted the risk assessment criteria for flooding and strong winds based on the latest data and established risk assessment tools for the energy system. Moreover, it strengthened the building of the energy industry's basic capacity for adaptation and promoted the independent management system of risk assessment for the energy industry to ensure the security and stability of the energy supply. In the area of industry, for the manufacturing industry, the "Climate Change Adaptation Management Procedure" has been formulated based on frameworks such as the TaiCCAT Climate Adaptation Supportive Tool (CAST), the Task Force on Climate-related Financial Disclosures (TCFD), ISO/DIS14091:2019 (climate change adaptation standard document). In the future, such a process will be used continuously to assist businesses in assessing transition risks and costs.

7. Agricultural production and biodiversity

The Phase II Action Plan in the area of agricultural production and biodiversity includes six major adaptation strategies: maintaining agricultural production resources and environment, developing climate-smart agricultural technology, adjusting agricultural business models and strengthening early warning and adaptation mechanisms for production and sales, building disaster early warning and response systems, enhancing the agricultural disaster relief and insurance system, performing regular monitoring and reinforcing the management of protected areas. There are nine priority adaptation action plans in this area.

Currently, in terms of maintaining agricultural production resources and the environment, organic agriculture has continued to be promoted, which has grown by 14.53% since 2017. In the development of climate-smart agricultural technology, a germplasm preservation project was implemented to preserve the germplasm and genetic information of agriculture and animal husbandry in the database. In addition, the research and development of high-resilience species as well as breeding methods were

strengthened. In terms of adjusting the agricultural business model and strengthening the early warning adaptation mechanisms for production and sales, the action plans promoted facility-based agricultural projects, developed greenhouse agriculture with strong disaster prevention capabilities, and established the early warning mechanisms for the production and sales of agricultural products. In terms of building disaster early warning and response systems, the action plans increased the sources of observation station data for the agrometeorological early warning platform and promoted customized services such as apps and cultivation calendars. In terms of strengthening the agricultural disaster relief and insurance system, the action plans continued to increase the number of insurance products to expand the coverage of insurance; the insurance coverage ratio has gradually increased, which has grown to 22.98% since 2017. In addition, the action plans also promoted the legislation of the "Agricultural Insurance Act." In terms of performing regular monitoring and reinforcing the management of protected areas, the action plans continued to improve the national biodiversity indicator monitoring and reporting system and strengthen marine ecosystem surveys and coastal ecology conservation.

8. Health

The Phase II Action Plan in the area of health aims to strengthen the prevention, disaster reduction, response, and recovery capabilities of the medical, health, and epidemic prevention systems and to improve the management of health risk monitoring, impact assessment, and prevention.

In terms of water quality monitoring, the action plans regularly monitor the water quality of environmental water bodies and establish a long-term historical trend. In terms of air quality monitoring, the air quality monitoring system was continuously checked. In terms of the prevention and control of acute infectious diseases, the action plans continued to promote the prevention and control of infectious diseases related to vector, intestinal, zoonotic, and flood-related diseases and improved the notification and management system for cases and epidemic prevention materials. In terms of high/low temperature prevention and control, various channels are used to educate the public about the risk of heat hazards and to strengthen care. In addition, the action plans also strengthened the low-temperature health care and cardiovascular disease prevention measures for the public during a cold wave. In terms of risk assessment of environmental protection business, the existing environmental protection business is analyzed, and suggestions are made for air quality (thermal pressure), water quality, and mosquito control. In terms of the emergency medical rescue mechanism, the action plans continued to carry out disaster prevention drills, guide local health authorities to respond to the potential characteristics of regional disasters, and organize emergency medical rescue drills for a large number of injured and sick patients from climate change-related disasters across counties and cities, strengthen pre-exercise training, assessment, and review, and continue to entrust the regional medical emergency operation centers to conduct disaster response education training and drills, strengthening the disaster response capabilities of medical personnel.

References

1. IPCC, Climate Change 2014–Impacts, Adaptation and Vulnerability: Regional Aspects, 2014.
2. Knutson, Thomas R., John L. McMcbride, Johnny chan, Kerry emanuel, Greg Holland, Chris Landsea, Isaac Held, James P. Kossin, A. K. Srivastava and Masato Sugi, Tropical cyclones and climate change, Nature Geoscience, 2010.
3. Environmental Protection Administration, Executive Yuan, "Summary of 2020 National Climate Change Adaptation Action Plan Annual Report," 2020: https://adapt.epa.gov.tw/dispPageBox/files/Summary of 2020 National Climate Change Adaptation Action Plan Annual Report (approved version).pdf.
4. Environmental Protection Administration, Executive Yuan, "2018 National Communication of the Republic of China (Taiwan) under the United Nations Framework Convention on Climate Change," 2018:https://unfccc.saveoursky.org.tw/nir/tw_nc_2018.php.
5. Environmental Protection Administration, Executive Yuan, Taiwan Adaptation Platform: https://adapt.epa.gov.tw/.
6. Ministry of Science and Technology, "Scientific Highlights of the IPCC Sixth Assessment Report (AR6) on Climate Change and the Update Report on Climate Change Review and Analysis in Taiwan," 2021: https://tccip.ncdr.nat.gov.tw/km_abstract_one.aspx?kid=20210810134743.

7. National Development Council, "National Climate Change Adaptation Action Plan (2018-2022)," 2019: https://adapt.epa.gov.tw/TCCIP-1-F/TCCIP-1-F-4.html.
8. National Development Council, "National Climate Change Adaptation Action Plan (2013-2017)," 2014: https://www.ndc.gov.tw/cp.aspx?n=FCB2E59927B8AFFD
9. National Development Council, "Report on the Implementation Results of National Climate Change Adaptation Action Plan 2013-2017," 2018.
10. National Development Council, "Adaptation Strategy to Climate Change in Taiwan," 2012: https://adapt.epa.gov.tw/dispPageBox/files/756.pdf.
11. Environmental Protection Administration, Executive Yuan, "National Climate Change Action Guideline" 2017: https://ghgrule.epa.gov.tw/action/action_page/50.
12. National Science and Technology Center for Disaster Reduction, Atlas of Key Indicators of Climate Change in Taiwan, 2019: https://tccip.ncdr.nat.gov.tw/upload/activity_agenda/20190930104520.pdf.
13. Taiwan Climate Change Projection Information and Adaptation Knowledge Platform project, "The Past and Future of Taiwan's Climate: Taiwan Climate Change Scientific Report 2017 - Highlights of Physical Phenomena and Mechanisms," 2018: https://tccip.ncdr.nat.gov.tw/upload/book/20181112092940.pdf.
14. Taiwan Climate Change Projection and Information Platform project, "Taiwan Climate Change Scientific Report 2017 - Physical Phenomena and Mechanisms," 2017: https://tccip.ncdr.nat.gov.tw/upload/book/20180410112426.pdf.

Chapter 6

Climate Change Scientific Research and Observations

6.1 Climate Change Scientific Research

6.2 Climate change meteorological observation

Chapter 6 Climate Change Scientific Research and Observations

To achieve the goals of the "Paris Agreement," countries around the world must jointly promote the innovative development and application of global greenhouse gas reduction and adaptation technologies, and establish a stable meteorological observation system as well as accurate weather forecasting models to grasp the possible impact of climate change. Taiwan has invested resources in the research and observation of climate change and shared the results with the world through international collaboration.

The first part of this chapter introduces the strategies, projects engaged, and the integration, as well as application of the project, results for promoting climate change research in Taiwan, while the second part introduces the current status of meteorological observation in Taiwan, including meteorological, marine weather and hydrological systems, as well as the application of meteorological data in climate change.

6.1 Climate Change Scientific Research

The Ministry of Science and Technology is the central competent authority for scientific research and technology development in Taiwan. It coordinates plans and strategies for Taiwan's overall scientific and technological development, including climate-change-related scientific research. In addition, the Ministry of Science and Technology also promotes cross-domain integrated research projects, builds Taiwan's critical capabilities for climate simulation, prediction, and data interpretation, and participates in the implementation of climate-change-related policies for various ministries and councils (or committees). This section first describes the promotion and management mechanism of Taiwan in carrying out the overall climate change scientific research and explains the key measures and results of Taiwan's climate change scientific research based on the three aspects of "climate change fundamental research," "cross-domain integrated research" and "climate-change related policies implemented by the Ministry of Science and Technology."

6.1.1 Promotion and management mechanism of climate change scientific research

According to the provisions of the "Fundamental Science and Technology Act," the Executive Yuan convenes the "National Science and Technology Conference" every four years, which serves as an important platform for the nation to coordinate science and technology policies. After the Conference, the "National Science and Technology Development Plan" was released, acting as the basis for various sectors across the country to promote science and technology policies. The implementation of the "National Science and Technology Development Plan" is managed and evaluated by the Ministry of Science and Technology, and the results are reported to the Executive Yuan every year.

Since the 6th National Science and Technology Conference in 2020, climate change issues have been incorporated into Taiwan's science and technology development policies. Four goals, 15 sub-goals, and 44 strategies were proposed in the latest issue of the "National Science and Technology Development Plan (from 2021 to 2024)," with "Smart Innovation, Inclusive Transition to Low Carbon, Health, and Sustainability" as the major focuses. Among them, the directions of scientific and technological development directly related to addressing climate change are as follows:

1. Improve adaptation and refine early warning of disasters: improve climate change resilience and the service capacity of scientific research.
2. Diverse investment in forward-looking green energy technology: strengthen the development of green energy technology.

To assist various ministries and councils (or committees) in realizing the above-mentioned vision, the Ministry of Science and Technology has put forward a "Strategic Blueprint for Science and Technology Development" in accordance with the "National Science and Technology Development Plan," serving as the action plan. The latest issue of the "Strategic Blueprint for Science and Technology Development" focuses on the challenges encountered by the country and society at present and sets the "Five Major Issues" and the

Figure 6.1-1: Latest issue of Taiwan's "Strategic Blueprint for Science and Technology Development"

Source: Strategic Blueprint for Science and Technology Development (from 2019 to 2022)

"Twenty Coping Strategies" for the period from 2019 to 2022, as well as the "Scientific Exploration and Technology Planning" for the future, as shown in Figure 6.1-1.

In this Blueprint, the issue directly related to addressing climate change is "energy, resources, and the environment." The focus is to build a green and low-carbon environment and strengthen the capabilities in preventing and reducing disasters. The coping strategies are as follows:

1. Environmental quality: Build an environmental sensing network to improve detection capacity; strengthen the incentives for greenhouse gas reduction to increase the involvement of the industries; reinforce recycling technology to expand the benefits of demonstration sites.
2. Energy supply and demand: Implement energy conservation and carbon reduction to improve energy efficiency; incorporate innovative models to promote energy development; strengthen smart grids to stabilize power supply quality.
3. Disaster risk management: Establish a cross-border risk governance structure to optimize disaster risk control; effectively collect and utilize disaster-related information and data to strengthen disaster early warning capacity and cultivate related industries.

The "Scientific Exploration and Technology Planning" for the future will focus on "Intelligence, Health, Sustainability, and Scientific Exploration." Among them, the highlights for the planning of scientific and technological development directly related to addressing climate change are as follows:

I. Promoting the utilization of energy and resources

1. Recyclable high-value materials:

Develop recyclable high-value materials and key material technologies required for recycling processes.

2. Recycling technology:

Develop new technologies to recycle organic, inorganic, and electronic waste to reduce the consumption of natural resources.

3. Production chain integration planning:

Learn from the natural ecosystem to promote industrial symbiosis and resource integration, so that factory waste and thermal energy can be utilized by neighboring units. Guide operators to transform from waste management to resource recycling and circular economy.

II. Developing high-efficiency and low-carbon energy

1. Alternative energy:

Develop cost-effective solar cell and module technology, offshore wind turbine engineering capabilities, biomass energy, etc.

2. Smart grid:

In response to the intermittent nature of renewable energy, power distribution is regulated through information communication and automation technologies to improve the quality and stability of power supply.

3. Energy storage technology:

Develop energy storage and system integration technology to serve as buffers for the power system, which is used by power vehicles such as electric cars.

4. Advanced energy-saving technologies:

Reduce energy consumption from the demand side and enhance the global competitiveness of industrial products.

III. Building a resilient homeland for disaster prevention and pollution reduction

1. Smart disaster prevention system:

Establish a smart and automated monitoring and early warning system, allowing the government and the public to implement disaster prevention measures as early as possible.

2. Environmental quality monitoring:

Combine international disaster prevention technologies and Taiwan's information system to develop a disaster monitoring and prediction system that is appropriate for the complex terrain of Taiwan.

3. Climate change research:

Combine local information and changes in the global climate model to build a local climate modeling system, serving as the basis for formulating climate change adaptation strategies.

6.1.2 Key measures and results of climate change scientific research

I. Climate change fundamental research

Global climate change is one of the important scientific and technological R&D projects in various countries, of which the prediction of regional climate change trends and their impact are the main directions for fundamental research and development.

Regarding the research on Taiwan's local climate change simulation model, the Ministry of Science and Technology began to promote the independent development of Taiwan's climate simulation system in 2011 and supported the climatologists from the Academia Sinica and related universities to organize the "Taiwan Climate Simulation System Development Team." The Team completed the Taiwan Earth System Model (TaiESM) with a resolution of 100 km and the High-Resolution (25/50 km) Atmospheric Model (HiRAM), which are combined with an extremely high spatial resolution (3–5 km) regional model (WRF) to form a set of model groups capable of performing global and regional simulations to determine the possible impact of global climate change on East Asian climate and monsoon, as well as extreme weather in Taiwan (such as typhoon, extremely heavy rain, drought, etc.).

In recent years, on the basis of the above-mentioned scientific research and the fundamental research funds of the Ministry of Science and Technology, the Academia Sinica has further promoted the "Anthropogenic Climate Change: Analysis, Capability Improvement, and CMIP6 Participation" and participated in the Coupled Model Intercomparison Project Phase 6 (CMIP6: providing the scientific basis for the sixth climate assessment report of the Intergovernmental Panel on Climate Change) supported by the World Climate Research Programme on behave of Taiwan. The aim of the project is to explore the potential impact of future global warming on the world, East Asian climate systems, and Taiwan. The established Taiwan Earth System Model was used to simulate and predict climate change, providing locally produced information; this is the first time that Taiwan has provided global climate change prediction information to the international research community, evidencing Taiwan's scientific research strength.

The climate change simulation and prediction information produced by the Taiwan Earth System Model enhances the reliability of the specific climate change information predicted by the CMIP6 and makes it easier to understand. After evaluating a number of modern climate indicators, the Taiwan Earth System model ranks 8th out of 37 models in the world, on par with the model of the Meteorological Research Institute of JMA (Japan Meteorological Agency) in Japan, and outperforms other models in Asia (e.g., Korea and China). This project also completed the identification and confirmation of the climate dynamic mechanism that dominates future climate change, improving Taiwan's climate simulation capability and capacity to an international level and consolidating Taiwan's climate change research.

Based on the accumulation of research capacity in the aforementioned climate simulation models, the "Taiwan Climate Change Projection Information and Adaptation Knowledge Platform (TCCIP)" of the Ministry of Science and Technology, promoted by the National Science and Technology Center for Disaster Reduction in collaboration with various universities, ministries, and councils (or committee), has been closely working with the Academia Sinica to conduct a series of climate change simulations with HiRAM and WRF from the global scale to the regional scale (town and village) of Taiwan. It predicted the future trends of highly impacted weather events such as typhoons, torrential rains, afternoon thunderstorms, droughts, and heat waves under the influence of global warming. The information can be used to assess the impact of climate change on Taiwan's natural disasters, water resources, ecological environment, public health, agriculture, forestry, fishery, animal husbandry, society, economy, and people's well-being, and plan adaptation strategies accordingly.

The Ministry of Science and Technology has long been engaged in fundamental research, supporting comprehensively outstanding academic teams to make scientific breakthroughs and pursue academic excellence, and encouraging mutual data sharing and cooperation between projects to strengthen links with the international community.

II. Cross-domain integrated research

Since 2017, the Ministry of Science and Technology has integrated the previously promoted climate change scientific research project: "Taiwan Climate Change Projection Information and

Adaptation Knowledge Platform (TCCIP)." The entire project spans from March 1, 2017, to July 31, 2022, and has launched new services for Taiwan's climate science. TCCIP is the most important climate information service platform in Taiwan, which integrates climate scenarios, risk information, and climate services of adaptation tools. It has provided tested and evaluated climate information to the government, industry, research institutions, or the public to implement scientific research applications.

Currently, the construction and services of the Platform are in phase three. The main goal is to strengthen risk assessment and adaptation tools to support the government in promoting the "National Climate Change Action Guideline." The Platform is currently coordinated by the National Science and Technology Center for Disaster Reduction, Ministry of Science and Technology, and the information services provided have begun to take shape.

TCCIP has compiled 1.5 billion entries of climate change data as well as 100,000 pictures, homogenized and gridded Taiwan's climate change data, and improved the temporal and spatial resolution of the data. With regards to the domestic climate data, the meteorological observation data in Taiwan from 1897 to 2020 has been compiled. The scale of international meteorological data was originally 250 km. After being integrated and converted into a 5-kilometer scale suitable for Taiwan's assessment needs, it will be of great help to the scientific research and application of Taiwan's climate change impact and adaptation, as well as the formulation of future national adaptation policies.

Currently, the Platform has authorized users to download the gridded 5-kilometer observation data and the downscaled climate change projection data. If the government or research institutes have special needs, they can also contact the Platform for assistance. In the application of climate information, 19 API services for climate change information have been established for those in need. In 2018, the "Adaptation Resource Kit (ARK)" knowledge system was established to comprehensively analyze domestic and foreign adaptation frameworks, collect a large number of adaptation cases at home and abroad (divided into 7 major areas such as agriculture, fishery, water resources, flooding, sloping land, coast and public health), maintain close communication with stakeholders, and regularly review the development direction with experts and scholars from all walks of life through symposiums. ARK combines climate change hazards and impact indicator map, domestic and foreign adaptation plan development process, and SOBEK flooding module. SOBEK superimposes the projection results, policy measures, and geographic information, serving as the reference for formulating adaptation policies.

Through the translation of climate change knowledge, promotion platform services, increasing the number of users, and enhancing the public's understanding of climate change and adaptation and knowledge in addressing related issues, such as collecting or compiling important international scientific research and technical reports on climate change, and regularly issuing e-newsletters to provide externally climate change cover stories, TCCIP latest news, climate change news, etc. As of September 2021, nearly 1,500 people have subscribed to the e-newsletter. Moreover, special books, technical reports and information documents have been published, serving as references for understanding, and applying climate change data.

In addition, TCCIP was invited to participate in the preparatory decision-making committee of the UK's Adaptation Research Alliance (ARA), actively engaged in the EU's transnational integration plan - Knowledge Exchange between Climate Adaptation Knowledge Platforms (KE4CAP), and exchange data provision, data application experience and related technologies with Japan's Integrated Research Program (TOUGOU) and Climate Service Center Germany (GERICS).

III. Climate change related policies implemented by the Ministry of Science and Technology

1. National Energy Program (NEP)

The "National Energy Program" is the guiding framework for promoting the development of energy science and technology in Taiwan. The latest phase (2014-2018) of the Program integrated the existing energy-related research projects from the Ministry of Science and Technology, the Bureau of Energy (MOEA), the Industrial Development Bureau (MOEA), the Bureau of Standards, Metrology and Inspection (MOEA), the Department of Industrial Technology (MOEA), the Central Geological Survey (MOEA), the Institute of Nuclear Energy Research (Atomic Energy Council, Executive Yuan), and the Institute of Transportation (MOTC), and the key achievements are as follows:

(1) Energy saving:

Conduct energy-saving system R&D and services focusing on both key component development and system integration. It emphasized the needs of the industry to promote energy-saving technologies based on the four major aspects of residential & commercial energy saving, industrial energy saving, transportation energy saving, and school energy saving.

(2) Alternative energy:

Include three themed projects of biomass energy, solar energy, and energy storage. Through developing and promoting clean alternative energy, the use of fossil energy can be reduced. In addition, domestic alternative energy related industries were strengthened and cultivated to increase the scale of renewable energy development.

(3) Smart grid:

Carry out management and promotion according to domestic advanced metering infrastructure (AMI) or smart meters, renewable energy, electric vehicles, and electric energy demand. A Smart Grid Demo Site and a Virtual Power Plant (VPP) Demo Site were established to fully promote the smart grid industry.

(4) Offshore wind power and marine energy:

Based on offshore wind power and Kuroshio power, the numerical analysis of the R&D of ocean current power generation related technologies was completed. In addition, the R&D of marine construction environment and short-term forecast technologies, as well as the integration of O&M (operation and maintenance) decision-making technologies were completed, including marine meteorological data, offshore forecast data, wind farm data, and operation data monitoring, etc., enhancing the O&M capacity of local offshore wind farms.

(5) Geothermal and natural gas hydrate:

Researches on non-volcanic and volcanic geothermal system have been conducted. In recent years, the technologies that have been actively developed include organic Rankine cycle (binary type) power generation systems, geothermal reservoir management and monitoring technology, and scaling inhibition technology. At the same time, the R&D of acid-resistant coating technology and acid-resistant pipes was reinforced. Furthermore, underwater detection equipment was also developed to improve the accuracy of geothermal detection.

(6) Carbon reduction and clean coal:

Carbon capture, storage, and utilization (CCSU) technologies, as well as new combustion systems, were developed. The applications of carbon reduction technologies in the energy industry, including the use of low-carbon fuels, power unit efficiency improvement, and exhaust gas recovery, were promoted.

2. Forward-looking Infrastructure Development Program

The Ministry of Science and Technology, in cooperation with the country's overall plan to promote green energy technology and industrial innovation, assisted the development of the core area of the "Shalun Smart Green Energy Science City" under Taiwan's "Forward-looking Infrastructure Development Program," and completed the surrounding infrastructure. Among them, the Construction of Infrastructure for the Low-carbon Smart Environment, which is the highlight of the Science City, is briefly described as follows:

(1) Construction of Infrastructure for the Low-carbon Smart Environment

The project constructed a low-carbon smart transportation system, smart ecological parks, self-driving car test site, and related infrastructure, gradually introduced green energy-related infrastructure systems, and combined research laboratories of universities, Taiwan Sugar Corporation, and the Convention and Exhibition Center as well as business districts of Tainan City Government to attract domestic and foreign companies and organizations to station in, accelerating the development of Shalun Smart Green Energy Science City.

(2) Green Energy Technology Joint R&D Program

Through industry-university collaborative research, projects in four major areas of energy saving, energy generation, energy storage, and system integration are supported to improve the interactive relationship between technology R&D effectiveness and industrial development, powering the development of emerging green energy industries to lead industrial transformation.

6.2 Climate change meteorological observation

Meteorological observations can be roughly divided into three types, namely surface meteorological observations, upper-air meteorological observations, and special meteorological observations, due to differences in the scope, items, purposes, and methods of observations:

1. Surface meteorological observation means that observers use visual or meteorological instruments placed on the surface of the earth to observe various meteorological elements at the bottom layer of the atmosphere close to the ground. Meteorological observations made on ships at sea are also regarded as surface meteorological observations since the meteorological elements observed on ships are nearly the same as those observed on land, with only a few additional observation items related to oceanic elements.
2. Upper-air meteorological observation mainly refers to the use of free-floating balloons carrying meteorological instruments to observe meteorological elements at various altitudes, such as air pressure, temperature, humidity, and wind. The altitude range is usually about 40,000 meters or less, or use free-floating balloons to measure the wind direction and wind speed only at various altitudes according to its floating trajectory.
3. Special meteorological observation refers to the meteorological observation that does not fit into the first two categories and is made with special equipment or instruments for special purposes, such as lightning observation, meteorological radar observation, and meteorological satellite data reception and processing.

I. Promotion and management mechanism of meteorological observation

According to the "Meteorological Act," the competent authority for meteorological observation in Taiwan is the Ministry of Transportation and Communications (MOTC), and the related operations are performed by the Central Weather Bureau of the MOTC. The Central Weather Bureau of the MOTC is in charge of the planning, construction, management, and R&D of meteorological services across the country. The meteorological observation services performed by the Central Weather Bureau of the MOTC include ground meteorological observation, upper-air meteorological observation, meteorological satellite observation, and meteorological radar observation. In addition, it also conducts marine weather observations, including tides, waves, sea temperature, etc., as well as other atmospheric physical and chemical observations, including ozone, rainwater pH, UV index, etc.

II. Monitoring System of Taiwan Meteorological Observation

1. Surface and upper-air meteorological observations

Currently, Taiwan has 25 synoptic stations, two upper-air weather stations, and three observation stations. In addition, 12 cooperative and 576 automatic observation stations are set up to strengthen regional heavy rain monitoring, forming a complete network of rainfall and meteorological data collection stations, as shown in Figure 6.2-1. The meteorological elements observed daily at each station include weather conditions, wind direction, wind speed, cloud cover, cloud shape, cloud (base) height, visibility, air temperature, humidity, air pressure, precipitation, evaporation, sunshine hours, daily radiation, and soil temperature. Among them, the automatic observation station is mainly used to monitor rainfall, wind direction and speed, air pressure, temperature, and relative humidity, while the upper-air meteorological station focuses on monitoring items such as wind direction, wind speed, temperature, humidity, and air pressure. The items are observed once a day and every six hours when a special weather condition is approaching or when a typhoon strikes.

2. Satellite observation

The Central Weather Bureau, Ministry of Transportation and Communications regularly receives and handles meteorological data from satellites such as "Geostationary Meteorological Satellites," "Polar-orbiting Meteorological Satellites," and Taiwan's "FORMOSAT Satellites." Currently, dozens of basic satellite images and related derivatives for weather and environmental monitoring applications have been produced, including true-color images, cloud cover, day and night fog, rainfall, insolation, surface temperature, sea surface temperature, atmospheric wind field, aerosol optical depth, PM2.5, fire point detection, and sandstorm,

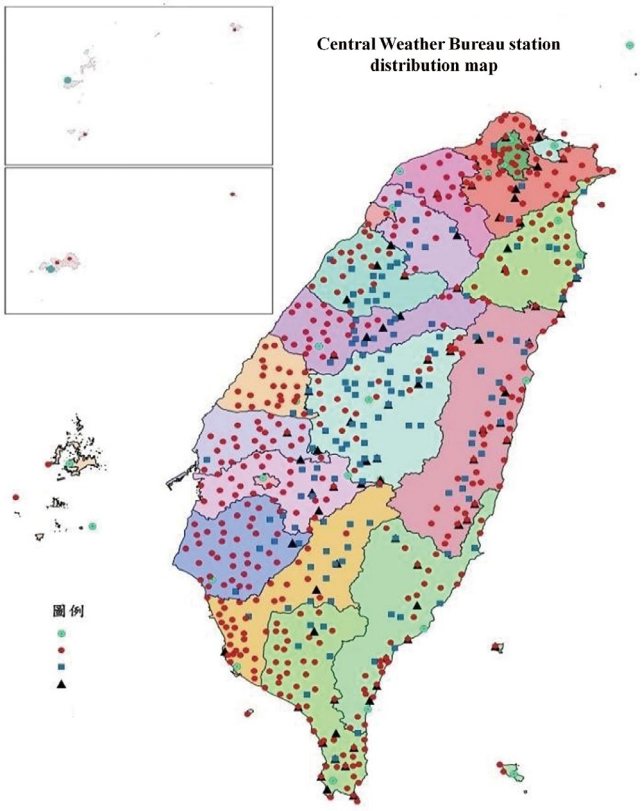

Figure 6.2-1: Map of observation stations of the Central Weather Bureau, MOTC

Source: Meteorological Annual Report of the Central Weather Bureau, Ministry of Transportation and Communications (2019)

serving as a reference for the forecasting operations of the Central Weather Bureau, and for the use by the environmental and energy sector, relevant academic groups, media, and the general public, as shown in Figure 6.2-2.

The "Geostationary Meteorological Satellites" receive information from a total of 5 satellites, including Japan's "Himawari-8," China's FY-2E, FY-2G, FY-2F, and South Korea's COMS, using Himawari-8 as the main source. The "Polar-orbiting Meteorological Satellites" receive information from a total of 9 satellites, including the US NOAA satellites, EOS satellites, Suomi NPP, and EU Metop A/B/C.

The "FORMOSAT-5" and the "FORMOSAT-7" are satellites used for meteorological observation in Taiwan, of which "FORMOSAT-7" is the result of the collaboration between the National Space Organization (NSPO) of Taiwan and the National Oceanic and Atmospheric Administration (NOAA) of the United States, which consists of six microsatellites that can provide about 4,000 entries of data per day between 50 degrees north and south latitude, benefiting meteorological and climatic studies conducted in low latitude regions.

3. Weather radar observation

The terrain in Taiwan is steep, with significant variations. To minimize the number of blind spots on the terrain, there are 11 weather radar stations currently available to provide more comprehensive monitoring of the weather system, as shown in Figure 6.2-3. Among them, the S-band radars include three Doppler weather radars and one dual-polarization Doppler weather radar; the C-band radars are all dual-polarization Doppler radar systems, including three disaster prevention and rainfall monitoring radars newly built by the Central Weather Bureau to provide observation data that is produced from every two-minute scan and has a spatial resolution of 250 meters since 2017. It is expected that two more radars of the same type will be built by 2024.

The current radar observation network covers the land area of Taiwan and its adjacent waters. It conducts continuous detection 24 hours a day, completes a full airspace scan every 7.5 minutes, and

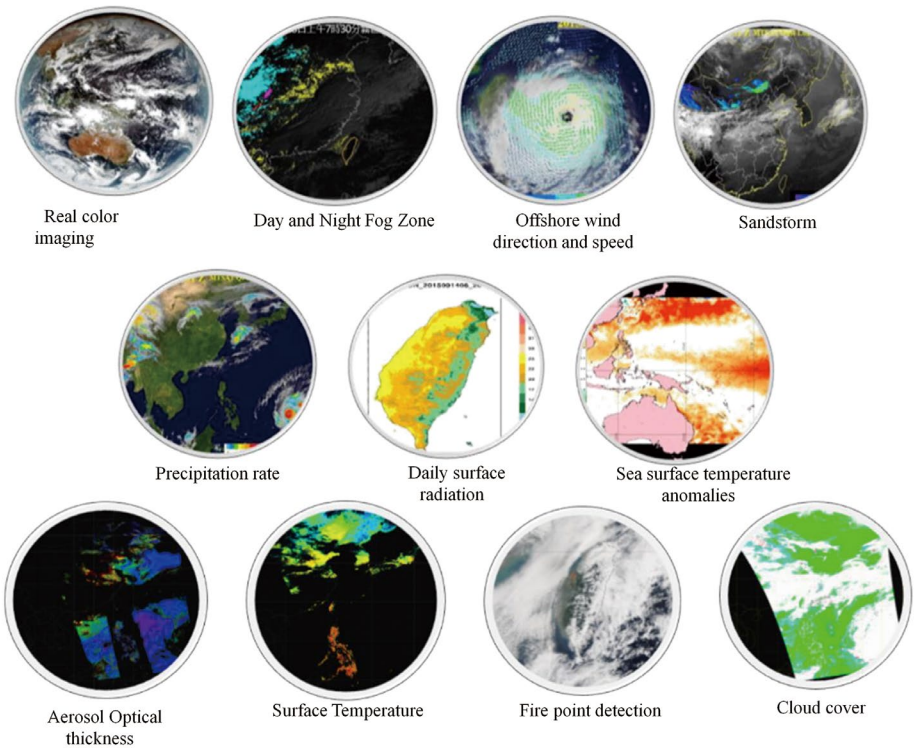

Figure 6.2-2: Various satellite derivatives produced by geostationary and polar-orbiting satellites

Source: Observation Annual Report of the Central Weather Bureau, Ministry of Transportation and Communications (2019)

updates it in real time so as to immediately grasp the dynamics of the weather system and analyze severe weather such as typhoons. The internal structure of the severe weather system is used to determine the development of the weather system, serving as an important reference for aviation, disaster prevention and response systems, and resource management in Taiwan.

Figure 6.2-3: Taiwan weather radar observation network

Source: Meteorological Annual Report of the Central Weather Bureau, Ministry of Transportation and Communications (2019)

4. Marine weather observation

Marine weather observation is further divided into wave observation and tidal observation. Wave observation mainly relies on data buoys; currently, there are 21 buoys. In addition to collecting marine weather data such as wave height, wave direction, and sea surface temperature, the data buoys also collect meteorological data such as sea surface wind direction, wind speed, air pressure, and temperature, serving as an outpost for gathering marine weather as well as meteorological data in the open sea during typhoons and providing an important reference for predicting the paths of typhoons as well as their intensities. The buoys can monitor the marine weather in the southern sea area of Taiwan, improving the marine weather forecasting capability of the region.

For tidal observation, there are currently 27 tide stations set up by the Central Weather Bureau, Ministry of Transportation and Communications, and another 40 tide stations set up in cooperation with other government agencies to monitor tides and storm surges caused by typhoons. Among them, 22 tide stations include observation sampling frequency and real-time transmission function for tsunami monitoring purposes, as shown in Figure 6.2-4. In addition to being used as an early warning mechanism for storm surge flooding and coastal protection, they also provide long-term water level monitoring, serving as a basis for national land surveying.

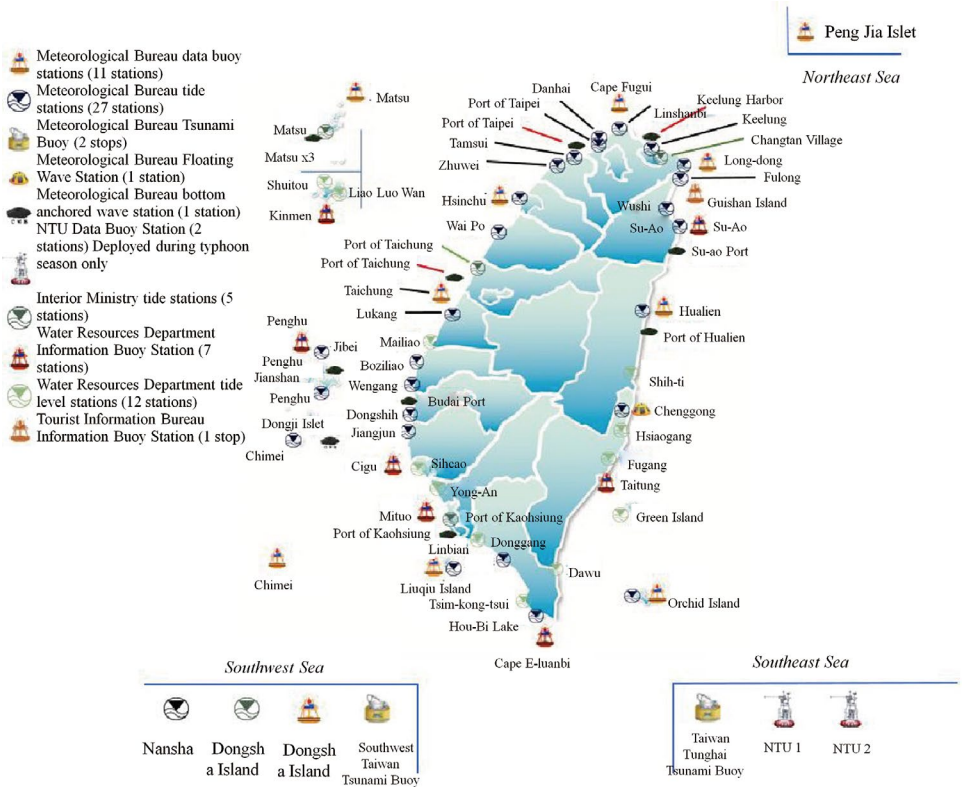

Figure 6.2-4: Taiwan marine weather monitoring network

Source: Meteorological Annual Report of the Central Weather Bureau, Ministry of Transportation and Communications (2019)

III. Integrated application of meteorological observation in Taiwan

1. Hazardous Weather Monitoring and Forecasting Systems Enhancement Project

The implementation period of the "Hazardous Weather Monitoring and Forecasting Systems Enhancement Project" is from 2010 to 2015. The Project comprehensively strengthened the meteorological monitoring and forecasting technology to prepare for the disasters that may occur due to climate change in the future. The specific results of the Project include:

(1) Introduced international advanced meteorological operations, improved the overall meteorological forecasting efficiency, and strengthened the disaster prevention function of the meteorological early warning mechanism.

(2) Implemented the results of the development of monitoring and forecasting technology in the past into practical operations.

(3) Improved professional cognition and judgment on issues related to climate change.

(4) Strengthened the monitoring and early warning (notification) efficiency for severe weather.

(5) Provided diversified and refined forecast information with high spatial and temporal resolution.

2. "Climate Change Application Service Capacity Development Project"

The implementation period of the "Climate Change Application Service Capacity Development Project" is from 2014 to 2017. Through meteorological observation and forecasting technology, assistance was provided to the government in conducting climate change risk management and formulating adaptation policies. The specific results of the Project include:

(1) Collection, processing and analysis of Taiwan's long-term climate data:
All observation data since 1897 have been checked, and the meteorological data since 1998 have been digitized and gridded as a priority. The database was further analyzed to make up for the inadequate data through projection, serving as the basis for quantifying the degree of outliers and anomalies in future observations and for error detection.

(2) Development of Taiwan's climate change analysis and projection technology:
The large-scale circulation index of extreme rainfall in Taiwan's plum rain season was established; the climate model proposed by IPCC was used to predict the trends of extreme rainfall under four greenhouse gas emission reduction scenarios; the effect of the East Asian and Northwest Pacific monsoons on ocean temperature was studied, which was used to analyze the ocean temperature in Taiwan; and the model developed by the "Climate Change Alliance" and the "Taiwan Climate Change Projection Information and Adaptation Knowledge Platform" was used to predict the trend of plum rain in Taiwan.

(3) Establishing a foundation for climate information application services:
The economic value that Taiwan's agriculture, animal husbandry, and aquaculture can bring by applying the meteorological information from the Central Weather Bureau to avoid climate disasters was estimated; actively participated in seminars on international climate services, and assist countries with diplomatic relations to establish meteorological monitoring and dengue fever early warning system.

(4) Promoting climate knowledge and information application services:
Climate change education forums were held in Taiwan; climate change educational videos and manuals were produced; the website of the Central Weather Bureau was improved by adding more climate change information and graphic-friendly interfaces.

3. "Project for Strengthening Taiwan's Marine Weather and Meteorological Environment Monitoring for Disaster Prevention"

The implementation period of the "Project for Strengthening Taiwan's Marine Weather and Meteorological Environment Monitoring for Disaster Prevention" is from 2015 to 2023. The Project aims to strengthen Taiwan's rainfall and sea area monitoring network and establish the marine weather and meteorological disaster prevention and environmental service platform. The specific results of the Project include:

(1) Completed the product database of the satellite product integrated display system, the

satellite product browsing interface, and the improvement of the system management function. Moreover, three geostationary satellite derivative products were added, which can improve telemetry data's application efficiency and service.

(2) The establishment of Taiwan's wave-tidal coupling model was completed. The storm tide forecasting technology (including the forecasting based on the typhoon paths of the Central Weather Bureau and TWRF wind field) was developed. Model testing using the typhoon results of NESAT was conducted. Development and application of ensemble forecasting system were carried out, and the creation, as well as application of multi-function user interface were provided.

(3) The "Taiwan Marine Weather Disaster Prevention and Environmental Information Platform" was established, which combines OpenStreetMap and the national land map of the Ministry of the Interior. The Platform has been implemented by the disaster prevention units of various organizations, including the Maritime Port Bureau, the Taiwan International Ports Corporation, the Coast Guard Administration, the Naval Meteorological and Oceanographic Office, the Water Resources Agency, the Tourism Bureau, National Park Management Offices, Ocean Conservation Administration (OAC), and the Chinese Petroleum Corporation, for disaster prevention and early warning, navigation safety, improvement of marine disaster prevention and rescue efficiency, and marine pollution prevention and control applications. The Project continued to expand the Taiwan Marine Weather Disaster Prevention and Environmental Information Platform and launch related services, build sea transportation area wave climate, coastal tidal line forecast, real-time tsunami analysis, and improve six disaster prevention operations and services such as the forecast for marine oil spill drifting, typhoon waves, abnormal sea temperature early warning, etc.

4. "Taiwan Climate Services Partnership"

In order to strengthen the capacity of various sectors in Taiwan to cope with climate risks, carry out national social climate adaptation work, and work in concert with the World Meteorological Organization (WMO) to implement international cooperation and promote industry-government-university-research public-private collaboration to enhance the capacity of climate services and jointly respond to the idea of global climate change risks and impacts, the Central Weather Bureau, Ministry of Transportation and Communications invited six major private organizations and think tanks related to meteorology, including the Meteorological Society of the Republic of China (Taiwan), the Chinese Aeronautical Meteorological Association (CAMA), the Meteorological Application &. Development Foundation (MADF), the Taiwan Meteorological Service Industry Development Association, the International Climate Development Institute (ICDI), and the Chung-Hua Institution for Economic Research jointly plan and launch the "Taiwan Climate Services Partnership (TCSP)." The future work and key tasks are as follows:

(1) Conduct research on issues, policy communication, and support: continue to track and analyze issues related to climate services and industrial development at home and abroad, propose policy recommendations in a timely manner, or promote research, collaboration, exchanges, certification, and licensing entrusted by the government and the private sector in order to facilitate the progress and development of related industries.

(2) Strengthen social dialogue and exchanges in meteorological services: promote information release and social communication of research results from all walks of life, strengthen public awareness of climate-related issues and preparations for adaptation to climate change, and hold forums, seminars, workshops, and other activities to promote meteorological dialogue and exchange within and outside the field.

(3) Promote the development of climate services and the meteorological industry: promote the exchange of information on meteorological services and related industries, provide climate service consultation and guidance, and assist in the connection between climate service supply and demand, as well as the construction of interactive models and markets.

(4) Support cross-field climate risk adaptation and information application: use the power of science to assist all walks of life in Taiwan to grasp climate risks and carry out impact adaptation, make full use of various climate (weath-

er) monitoring and projection data, and effectively combine the characteristics of various cross-field applications to carry out impact management, achieving the goal of reducing social risks and creating benefits.

Figure 6.2-5: Taiwan Climate Services Partnership held its 1st General Meeting on August 20, 2021

Source: Ministry of Transportation and Communications

References

1. Central Weather Bureau, Ministry of Transportation and Communications, "Summary of the Achievements of the Climate Change Application Capability Development Program (2014-2017)," 2017: http://conf.cwb.gov.tw/media/cwb_past_conferences/107/6. Cross-domain application of meteorology and environmental sustainable development /P-6-13-L_Liu Zaiming_Climate change response.pdf.
2. Central Weather Bureau, Ministry of Transportation and Communications, "2019 Meteorological Annual Report of the Central Weather Bureau," 2019: https://www.cwb.gov.tw/Data/service/notice/download/publish_20200926142859.pdf.
3. Communications, "2019 Observation Annual Report of the Central Weather Bureau," 2019: https://www.cwb.gov.tw/Data/service/notice/download/publish_20200930141244.pdf.
4. Meteorological Information Center of the Central Weather Bureau, Ministry of Transportation and Communications, "Meteorological Information Center Introduction Manual," 2017: https://www.cwb.gov.tw/V8/C/A/missions/MInfoC.pdf.
5. Ministry of Science and Technology, "ROC White Paper on Science and Technology (2015-2018)," 2013: https://www.most.gov.tw/most/attachments/03791ce9-0299-48f6-8c2c-b5d9d9c522f7.
6. Ministry of Science and Technology, "Strategic Blueprint for Science and Technology Development (from 2019 to 2022)," 2019: https://www.most.gov.tw/most/attachments/fe809e3c-a2d3-44e8-b8ed-11e0d77ccc82.
7. Ministry of Science and Technology, " Indicators of science and technology, Taiwan ," 2020: https://wsts.most.gov.tw/stsweb/technology/TechnologyDataIndex.aspx?language=C.

8. Ministry of Science and Technology, "Science City Infrastructure Plan - Ministry of Science and Technology," 2020: https://www.ey.gov.tw/File/306C8F4C3749F288.
9. Taiwan Climate Change Integration Service Platform of the Ministry of Science and Technology, TaiCCAT2014 Six Steps of Climate Adaptation: https://tccip.ncdr.nat.gov.tw/ark_02.aspx?p=TaiCCAT_2014.
10. Consortium for Climate Change Study, Ministry of Science and Technology, About Us: http://cclics.rcec.sinica.edu.tw/index.php/about-us.html.
11. Ministry of Science and Technology website, academic statistics database: https://wsts.most.gov.tw/STSWeb/academia/AcademiaInquire.aspx?language=C&sys=PR.
12. Ministry of Science and Technology website, forward-looking infrastructure projects promoted by the Ministry of Science and Technology: https://www.most.gov.tw/folksonomy/detail/115b4575-e85f-43cd-ab8f-13883a429a30?l=ch.
13. National Energy Program-Phase II: http://www.nepii.tw/language/zh/about/vision/.
14. Taiwan Science Data Processing Center, Brief Introduction of the missions of FORMOSAT-3 and FORMOSAT-7: https://tacc.cwb.gov.tw/v2/index.html.

Chapter 7

International Collaboration and Exchanges

7.1 Participation in the United Nations Framework Convention on Climate Change

7.2 Collaboration and exchanges between countries and intergovernmental organizations

7.3 Cooperation and exchanges between local governments and cities

7.4 Non-intergovernmental organization cooperation and exchanges

Chapter 7 International Collaboration and Exchanges

Climate change is critical to the sustainable development of all countries and the survival of the human species. It is an urgent challenge faced by the international community. Taiwan holds a unique political position internationally. Although it is excluded from the United Nations Framework Convention on Climate Change (UNFCCC), it still actively responds to global carbon reduction actions, taking the initiative to assume "common but differentiated responsibilities." Taiwan expands multilateral or bilateral climate change collaboration channels with various countries through collaboration and exchanges between multi-stakeholders such as national governments, local governments, industries, academic research, and civil society to enhance its international visibility and capacity building in climate actions. In addition, Taiwan integrates global and regional cooperation networks to share its experience and efforts in environmental protection, giving back to the international community and the countries in need.

7.1 Participation in the United Nations Framework Convention on Climate Change

Taiwan is currently not a member of the United Nations and has not been able to sign the UNFCCC and related agreements. Nevertheless, it has always complied with and implemented relevant international environmental conventions and norms, fulfilling its obligations and responsibilities as a member of the global village. In addition, Taiwan actively participates in climate convention-related conferences. The country promotes exchanges and collaboration with representatives of the industries, the government, universities, and research institutes from all over the world, offering sincere friendship as the foundation to build substantial cooperative relations with other countries. The important milestones are as follows:

1. During the pilot phase of the UNFCCC (1991),

Taiwan participated in the third and fourth meetings of the Intergovernmental Negotiating Committee (INC) as an observer of the Non-Government Organization (NGO).

2. In the implementation phase of the UNFCCC (from 1995 to present),

since the first UNFCCC Conference of the Parties (COP) and the meetings of its subsidiary bodies, Taiwan has continued to participate in the events as a non-governmental organization. Currently, there are 10 organizations registered as UNFCCC NGO observers. The important results of the UNFCCC COP 25 in 2019 are as follows:

(1)Thirteen diplomatic allies have helped Taiwan participate in the UNFCCC by writing letters or making positive assertions. In addition, members of the parliaments from 12 friendly countries, including the United Kingdom, Spain, Germany, Sweden, Hungary, Portugal, Chile, Ecuador, Mexico, Jordan, Lithuania, and Brazil, have helped Taiwan participate in the UNFCCC by writing letters to the Convention Secretariat, addressing inquiries to their country's administrative department or making public posts for Taiwan.

(2)The NGO observers of Taiwan have conducted a total of six side events: The three diplomatic allies of Taiwan, including Belize, Guatemala, and Tuvalu, have separately collaborated with the NGO observers of Taiwan, including the "Industrial Technology Research Institute" (ITRI), the "Mom Loves Taiwan," the "Taiwan Institute for Sustainable Energy (TAISE)" and the "Foundation of Taiwan Industry Service" to co-organized the UNFCCC side events, while the "Taiwan Research Institute," the "Delta Electronics Foundation" and the

"Taiwan Association of Sustainable Ecological Engineering Development" have separately worked with international NGO observers to co-organized the UNFCCC side events.

(3) The delegation of Taiwan, including the Deputy CEO of Executive Yuan's Energy and Carbon Reduction Office, Tze-Luen Lin, and representatives from the Council of Agriculture, Tainan City government, the Taiwan Youth Climate Coalition, and the International Cooperation and Development Fund were invited to attend 7 UNFCCC side events, present in seminars or participate in discussions, showing Taiwan's diverse capabilities.

(4) Taiwan's delegation held a total of 42 bilateral meetings with its diplomatic allies and friendly countries, extensively exchanging views with them to promote Taiwan's proposal: The delegation of Taiwan conducted a total of 42 bilateral meetings with its diplomatic allies and friendly countries with common ideas, such as the United States. During the bilateral meetings, the head of the delegation, Minister Chang, presided over a total of 16 meetings (meetings with one prime minister, five ministers, two ambassador-level representatives, eight senior negotiators or supervisors of the delegation).

(5) Members of Taiwan's delegation (including the Legislative Yuan Supervision Team and the International Cooperation and Development Fund) received a total of 12 media interviews: The head of the delegation received a total of 5 interviews, including the mainstream European media "The Voice of Germany," the third largest newspaper in Spain "Diario ABC" and "La Razón," and domestic media including the Central News Agency, the United Daily News, and the CommonWealth Magazine.

(6) Promotional activities received praise and positive feedback from all circles: Taiwan continued to use "Combating Climate Change-Taiwan Can Help" as the slogan to promote its efforts in fighting against climate change. Renewable green energy was adopted as the theme for the promotion, with "solar energy" and "wind power" as the main visual pattern. Advertisements were set up on the 8th MRT line that connects the venue and the Madrid–Barajas Airport, as well as bus stops near the venue. In addition, minibuses with advertisements were arranged to travel around the venue and the streets of Madrid's urban areas. The promotional activities received praise from international participants and positive feedback from domestic mainstream media, resulting in very effective propaganda that demonstrates Taiwan's ability and determination to contribute to the international community.

3. The plan for the 2021 UNFCCC COP 26 is as follows:

(1) The Conference was originally scheduled to be held in November 2020. However, due to the impact of the COVID-19 pandemic, it was postponed until October 31–November 12, 2021, in Glasgow, UK. Representatives of relevant ministries and NGOs in Taiwan organized a delegation to participate in the Conference. This year, Taiwan continued to ask the help from its diplomatic allies and friendly countries with common ideas to make assertions, write letters, organize side events, and arrange bilateral meetings, informing the international community of Taiwan's efforts in contributing to the fight against climate change.

(2) To improve the power of the proposal and strengthen its appeal, in addition to entrusting the "Taiwan Institute for Sustainable Energy" to hold the "2021 Climate Diplomacy and Sustainable Development Forum" from July 26 to 30 for the progress of international climate actions, a professional team was also commissioned to organize a campaign for promoting Taiwan's participation in the UNFCCC COP 26. It is hoped that through the use of social media and linking international youths who care about environmental issues to speak for Taiwan, the network of Taiwan's international partners can be further strengthened.

(3) 14 diplomatic allies have written official letters in appeal to the UNFCCC in support of Taiwan's participation in the UNFCCC. Taiwan's diplomatic delegation has held 30 bilateral talks with diplomatic allies, like-minded and friendly countries, and organizations on extensive policy topics such as energy transformation, renewable energy development, Net Carbon Zero by 2050, green finance, as well as carbon pricing, and promoting Taiwan's participation in the UNFCCC. In addition, Legislative Yuan

members Hong Shen-han and Hong Meng-kai traveled to the UK to carry out parliamentary diplomacy as well as bilateral exchanges. Taiwan's civil organizations co-organized side meetings with the AIA at the main venue.

(4) Taiwan participated in several peripheral conferences in the COP 26 venue. Among these conferences, three venues were respectively organized by NGOs (Industrial Technology Research Institute, Taiwan Industry Service Foundation, Mom Loves Taiwan, Green Club, etc.) and diplomatic allies (Belize, Palau, St. Kitts, and Nevis). Domestic NGOs also actively worked with foreign NGOs, as well as other invited speakers, to demonstrate the important role they play in Taiwan's participation in the UNFCCC. In order to increase Taiwan's capabilities in participating in international climate initiatives, Taiwan held a forum outside the COP 26 venue in The Hub building, involving Taiwan's regional governments, the US Environmental Protection Agency, the London School of Economics, international carbon market experts, and climate legal experts to discuss urban net zero and the implementation of policies, and the planning of Taiwan's long-term carbon reduction pathway and carbon pricing, etc.

4. Since 2002, Taiwan has been following the international standards recognized by the UNFCCC and continues to issue and update the National Communication, the National Greenhouse Gas Inventory Report, and the "Intended Nationally Determined Contribution (INDC)."

7.2 Collaboration and exchanges between countries and intergovernmental organizations

The Ministry of Foreign Affairs is the competent authority for Taiwan's international cooperation, and the International Cooperation and Development Fund is the planning and execution unit. The organization is a foundation established in accordance with the "Act for the Establishment of the International Cooperation and Development Fund." Its main responsibility is to assist the economic, social, and human resources development of diplomatic allies or other friendly partners of Taiwan and to provide humanitarian assistance to countries or international refugees suffering from natural disasters. The following will introduce the projects conducted by the International Cooperation and Development Fund for assisting partner countries in coping with climate changes according to Article 4, Paragraph 1, and Article 4, Paragraph 5 of the Paris Agreement based on the aspects of financial, technological, and capacity-building support.

7.2.1 Collaboration in investment and finance

1. Promotion of multilateral collaboration in climate finance

Limiting by its political situation, Taiwan is unable to participate in various multilateral climate cooperation platforms under the framework of the United Nations and the UNFCCC. Despite that, the International Cooperation and Development Fund has been financially supported by the government to assist diplomatic allies or other friendly partners of Taiwan in coping with climate changes through partners including the Asian Development Bank, the Central American Bank for Economic Integration, the Inter-American Development Bank, the Organization of American States, and the European Bank for Reconstruction and Development.

2. Result of multilateral climate finance cooperation: Financial Intermediary and Private Enterprises Investment Special Fund (FIPEISF) -Sustainable Agricultural Enterprise Value Chain Project

According to the 2017 estimation made by the Food and Agriculture Organization (FAO) of the United Nations, global food demand in 2050 will increase by 50% compared to 2013. Due to the limitations of capital, technology, and natural environment, developing countries will show slow growth in agricultural productivity. In the face of climate change in the future, the agricultural sector will be impacted the most, threatening the food security of developing countries.

Central Asia, the Mediterranean, and parts of Southeast Europe generally face the challenge of lack of water resources and reduction of arable land. In order to solve the food inadequacy problem and

avoid the increase in greenhouse gas emissions while taking into account the need for resilient agriculture in the future, Taiwan has collaborated with the European Bank for Reconstruction and Development since 2015 to assist eight agribusinesses in the region at the mid-end of the agricultural production chain to obtain funds required for operations or equipment.

In 2019, Taiwan and the European Bank for Reconstruction and Development (EBRD) expanded the scale of assistance to create the "Financial Intermediary and Private Enterprises Investment Special Fund (FIPEISF) -Sustainable Agricultural Enterprise Value Chain Project." Through the FIPEISF established by Taiwan in the EBRD, the EBRD has promoted sub-projects for the countries in the priority list provided by Taiwan, providing financial support for the upstream, middle, and downstream agricultural businesses. In addition, assistance from professional advisors was provided to ensure that the businesses have adopted environment-friendly and climate-resilient agricultural technologies, strengthening the recipient country's capacity to cope with climate change in the future. It also responded to Goal 12: "Ensuring sustainable consumption and production patterns" and Goal 13: "Take urgent action to combat climate change and its impacts" of the United Nations Sustainable Development Goals.

3. Promotion of bilateral climate finance cooperation

Through bilateral cooperation, Taiwan and its diplomatic allies or friendly partners have conducted projects that promote loans or investment for the public and private sectors, thereby helping the local economy and society to grow steadily and sustainably while building the capacity of the society as well as the industries to cope with climate change. The projects cover economic infrastructure and services, social infrastructure and services, and production sectors.

In terms of economic infrastructure and services, public infrastructure, microfinance, and micro/medium-sized enterprise refinancing projects were used to assist recipient countries in establishing sustainable economic models with climate resilience.

In terms of social infrastructure and services, educational facilities and environmental protection projects were used as tools to assist recipient countries in developing human resources and improving environmental and public health conditions. In addition to disaster assistance and post-disaster reconstruction, the design of the projects will also consider the long-term impact of climate change on the recipient countries.

As to the production sectors, agricultural enterprises and regional agricultural projects were used as tools to assist the production sectors of recipient countries, including agriculture, forestry, fishery, animal husbandry, and industry sector, improving production efficiency and coping with the impact of climate change.

4. Result of bilateral climate finance cooperation: Home Energy Efficiency and Renewable Energy Project in the Marshall Islands

Figure 7.2.1-1: The "Home Energy Efficiency and Renewable Energy Project in the Marshall Islands" conducted by the International Cooperation and Development Fund in the Marshall Islands; the members of the project hold a briefing to promote the Home Energy Efficiency and Renewable Energy Project

Source: International Cooperation and Development Fund

Figure 7.2.1-2: The "Home Energy Efficiency and Renewable Energy Project in the Marshall Islands" conducted by the International Cooperation and Development Fund in the Marshall Islands; Marshall Energy Company staffs visit homes to carry out energy audits

Source: International Cooperation and Development Fund

The Marshall Islands is an island country located in the North Pacific. Its energy supply is highly dependent on imported fossil fuels, reaching more than 90%, while solar energy only accounts for 1% of its total energy supply. For this reason, the government of the Marshall Islands formulated the National Energy Policy and Energy Action Plan in 2015. It is hoped that by 2020, the country's renewable energy percentage can reach 20% of its total power generation, the household energy efficiency can be improved by at least 50%, and the energy efficiency of government agencies can be boosted by at least 75%.

In 2016, the government of the Marshall Islands signed a contract with Taiwan to provide loans to the Ministry of Finance of the Marshall Islands and then on-lending to the Marshall Islands Development Bank (MIDB), offering loans to households who intend to improve energy efficiency.

There are two items in the project, which are the replacement of household energy-consuming appliances and lamps, and the installation of household solar energy systems. The execution unit of this project is the Marshalls Energy Company (MEC), which is responsible for assisting loan applicants in energy audits and providing energy improvement suggestions. The Marshall National Energy Office is responsible for the overall coordination of the plan.

7.2.2 Technical cooperation

1. Promotion of technical cooperation

Accelerating the research on technologies related to climate change and transferring them to developing and Underdeveloped countries is the responsibility of Paragraph 5, Article 4 of the Convention. Currently, the global technology transfer is coordinated by the Conference of the Parties (COP) under the framework of the Convention set up a "Technology Mechanism," under which there is a Technology Executive Committee (TEC) and Climate Technology Centre and Network (CTCN). The former is responsible for integrating global climate technology research and development policies, while the latter is a platform for guiding international cooperation in scientific research and development and transfer.

Due to its political situation, Taiwan is unable to use the "technical mechanism" established by the Convention to share technological research results with countries around the world. However, through the International Cooperation and Development Fund, Taiwan has conducted climate change-related technical cooperation with its diplomatic allies and friendly partners in accordance with the principles stipulated in the Convention for the technology development, technology diffusion, and technology transfer.

2. Case of technical cooperation: Solar PV Mini-Grid System for Lighting in Myanmar Rural Areas

Myanmar has a serious electricity shortage problem. According to the World Bank report, in 2014, only 30% of the country's population had access to supply mains. The situation is even worse in rural areas. By 2016, 2/3 of households were still unable to connect to the power grid, affecting people's daily life, education, health, and safety and hindering the development of local economic activities. Therefore, rural power supply and lighting are listed as important poverty alleviation strategies and national development goals by the Myanmar government.

This project was a pilot project conducted at the location designated by the Myanmar government. The execution agency is the Department of Rural Development (DRD), Ministry of Agriculture, Livestock and Irrigation, Myanmar, and the Industrial Technology Research Institute serves as the technical consultant. After the open bidding, Pino Technologies Co., Ltd. won the bid and is the contractor for building the system. This project utilized the advantage of Myanmar, which has stable and sufficient sunlight, combined with Taiwan's strength in solar photovoltaic technology as well as its industrial chain, to set up an off-grid centralized power supply system for rural areas that cannot be reached by the power grid in a short period, providing the electricity required for lighting of households and public facilities.

By allowing the villagers to participate in the construction work, they will increase their recognition and sense of responsibility for the project, which will benefit the operation and maintenance of the system. The project includes:

(1) Plan and build a mini-centralized solar power supply system and power-saving lamps.

(2) Assist the villagers in organizing a power supply

Figure 7.2.1-3: The "Solar PV Mini-Grid System for Lighting in Myanmar Rural Areas" project conducted by the International Cooperation and Development Fund in Myanmar; the villagers and the work team celebrate the completion of the power supply station

Source: International Cooperation and Development Fund

station management committee responsible for system operation and maintenance and provide the required education and training, including the organization and operation of the management committee, power station operation and maintenance, and the promotion and implementation of the charging mechanism.

(3) Verify system efficiency and power supply station operating conditions. Correct and establish appropriate power supply operating models based on actual conditions.

Three sets of mini-centralized solar photovoltaic systems and power-saving lamps have been built in Magway Region and Saiging Region in central and western Myanmar. After half a year of trial operation, it has provided stable electricity to five villages with a total of 560 households and temples, as well as other public facilities such as schools and streets for lighting. The project helped to establish two power management committees, and completed the training on power supply station operation and maintenance, payment mechanism, and operation management, as well as the electricity usage knowledge for the residents. After half a year of operation, the operation and charging mechanism are good.

In addition, this project provides a good reading and learning environment for school children, enables villagers to engage in economic activities such as night farming and household sideline businesses, and reduces their expenditures on the purchase of candles or kerosene, achieving both the sustainable development goals of inclusive growth and environmental protection.

7.2.3 Capacity building

1. Implementation of capacity building

Based on the strategies and goals of diplomatic allies and friendly partners, Taiwan has formulated a cooperation plan focusing on capacity building to adapt to climate change. Although the plan includes technology transfer, it pays more attention to establishing a long-term operation system in the local area. It gradually cultivates local talents through the establishment of demonstration units, expert consultation, technical training, and business guidance.

2. Case of capacity-building cooperation: Saint Kitts and Nevis

Located in the Caribbean Sea, Saint Kitts and Nevis suffered a severe drought in 2015. The crop output that year decreased by about 31.2% compared with the previous year. The assessment project conducted by Taiwan found that local agriculture is highly vulnerable. For this reason, improving the climate variability early warning capacity and the agricultural sector's ability to cope with long-term climate change was listed as one of the key cooperation projects between Taiwan and Saint Kitts and Nevis.

Figure 7.2.1-4: The "Enhancing Agricultural Adaptive Capacity to Climate Variability Project" conducted by the International Cooperation and Development Fund in Saint Kitts and Nevis; a field demonstration is carried out to explain how to use agrometeorological data for cultivation management and decision-making

Source: International Cooperation and Development Fund

Since 2018, Taiwan and the Ministry of Agriculture of Saint Kitts and Nevis have launched a 4-year "Enhancing Agricultural Adaptive Capacity to Climate Variability Project," which includes "establishing a mechanism for gathering early warning information," "developing or introducing crop disaster mitigation and prevention techniques," and "increasing the availability of agricultural information." As of March 2021, four agricultural weather stations, one model farm, and four model fields serving as a demonstration to farmers have been established. Through simulation of cultivation experiments for disaster prevention and mitigation, together with agrometeorological data collection and regular agricultural information promotion mechanism, suggestions on cultivation techniques that meet the concept of Climate Smart Agriculture (CSA) according to local conditions were provided to local farmers. In addition, this project also established an agricultural information integration platform and produced annual disaster reduction technical reports to assist Saint Kitts and Nevis in strengthening their agricultural production resilience.

Affected by the COVID-19 pandemic in 2020, the implementation details of this project were adjusted. Taiwan provided sweet potato seedlings to help increase the local production of rhizome crops by approximately 9.5 tons, helping disadvantaged families to overcome the food shortage crisis brought about by the pandemic.

3. International Human Resources Training Workshop Program

This program is conducted by the International Cooperation and Development Fund. The main purpose of this program is to cultivate professional talents in policy planning and related fields required for economic and social development for Taiwan's diplomatic allies and friendly partners. Among them, climate change is a key topic that is concerned by Taiwan and other countries.

To comply with international trends, respond to the needs of diplomatic allies and friendly partners and make good use of Taiwan's experience, including Taiwan's response to global climate change, experience in preventing and monitoring natural disasters caused by climate change, and green technology applications in various industries, workshops on climate change and related issues were held, allowing the attendees to know Taiwan's response to climate change and the experience on international involvement, which also serves as a reference for the attendees when they promote related policies in the future.

To deal with climate change issues, Taiwan conducted the International Human Resources Training Workshop in 2021. The schedule for the event is shown in Table 7.2-1.

Table 7.2-1: International Human Resources Training Workshop Program conducted in 2021

Training	Number of attendees	Duration
Online Workshop on Improving Energy Efficiency	20	2021/05/25；2021/05/26
Online Workshop on Marine Debris Solutions	20	2021/09/08
Online Workshop on Renewable Energy	20	2021/07/14；2021/07/15
Online Workshop on Environmental Monitoring and Infectious Disease Prevention	20	2021/09/29；2021/09/30
Online Workshop on Smart Water Management	25	2021/10/15；2021/10/26
Online Workshop on Circular Economy of SMEs	25	2021/10/27
Online Workshop on Agrotechnology	25	2021/07/27；2021/07/28
Online Workshop on Resilient Agriculture	25	2021/11/10

Source: International Cooperation and Development Fund

Figure 7.2.3-1: The "Workshop on Circular Agriculture Promotion (exclusive for Asia Pacific)" conducted by the International Cooperation and Development Fund; attendees visit the field application of biocarbon

Source: International Cooperation and Development Fund

4. International Environmental Partnership

The "International Environmental Partnership (IEP)" was jointly established by the Environmental Protection Administration of Taiwan and the Environmental Protection Agency of the United States in 2014, serving as a platform to assist developing countries in the Asia-Pacific region in exchanging environmental regulations and technologies. As of July 2020, the IEP has helped more than 80 international environmental agencies and organizations in more than 60 countries to carry out cooperation projects and exchange activities. The projects cover various fields such as air pollution, electronic waste, environmental law enforcement, and environmental education. Among them, environmental education is the most relevant to climate change.

When the IEP was established in 2014, environmental education leaders from various countries were invited to discuss how to face climate change issues through environmental education and citizen participation. During the meetings, all countries agreed on the need to establish a centralized platform for sharing environmental education cases and resources. Therefore, the Environmental Protection Administration of Taiwan, the Environmental Protection Agency of the United States, and the North American Association for Environmental Education established the "Global Environmental Education Partnership (GEEP)" to promote environmental education in three aspects, namely strengthening the network, building leadership, and promoting outstanding cases.

Currently, the "Global Environmental Education Partnership" has become an integrated platform for international environmental and climate education. Those conducting climate actions can quickly check the national environmental and climate education policies in countries around the world on the website and contact local environmental institutions and organizations participating in the "Global Environmental Education Partnership" network to carry out further climate education action with the assistance of senior consultants. In addition, the platform can also provide climate education cases from different countries as references for the climate education and training of various countries.

7.3 Cooperation and exchanges between local governments and cities

7.3.1 ICLEI-Local Governments for Sustainability

The ICLEI (International Council for Local Environmental Initiatives, Local Governments for Sustainability) (hereinafter referred to as the ICLEI) was established in New York in September 1990 when the United Nations held the World Congress of Local Government for a Sustainable Future. Its current members include 12 megacities, 100 supercities and metropolitan areas, 450 big cities, and 450 medium/small-sized cities and towns in 86 countries. More than 1,000 local governments have become members, and it is the world's largest international organization of local government network that promises sustainable development.

A total of 11 cities in Taiwan have joined the ICLEI, namely Taipei City, New Taipei City, Taoyuan County, Hsinchu City, Taichung City, Yunlin County, Chiayi County, Tainan City, Kaohsiung City, Yilan County, and Pingtung County. In recent years, Taiwan has taken the initiative to promote local government policies and actions for energy saving and carbon reduction. In addition to actively constructing a legal foundation and policy measures in response to climate change, the Environmental Protection Administration also invited experts to share ICLEI's strategies and successful experience in promoting low-carbon city partners around the world. Currently, Kaohsiung City has established the "ICLEI Kaohsiung Capacity Center (ICLEI KCC), serving as the East Asia

operation center to perform the tasks assigned by the ICLEI World Secretariat and offer support to various offices in East Asia, providing member training, professional knowledge, and information exchange on the management of various environmental sustainability policies.

In addition, Taoyuan City has signed a contract with the ICLEI in 2019 to become the world's first Chair City for the eco-logistics community to carry out eco-logistics initiatives such as green energy, smart warehousing, and low-carbon transportation and is committed to reducing the packaging and energy consumption of merchandises in the transportation process. Currently, it is planning the five characteristic fields of eco-logistics to market Taoyuan's sustainable development capability to the world. At the ICLEI World Congress 2021, Mayor Cheng Wen-Tsan of Taoyuan City was invited to give a speech at the first meeting of the ICLEI Global Executive Committee (GExCom) as the Chair of eco-logistics. As the pandemic spreads around the world, countries worldwide rely on the logistics industry to maintain the daily necessities of people and supply chains. Taoyuan's logistics industry accounts for 80% of the nation's total, making eco-logistics initiatives and practices particularly important.

7.3.2 CityNet

"CityNet" was established in 1987 with the support of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), the United Nations Development Programme (UNDP), and the United Nations Human Settlements Programme (UN-Habitat), dedicated to the sustainable development of the Asia-Pacific region. It is headquartered in Seoul, Korea, and currently has 110 full members, 58 associate members, and five corporate members. In addition, there are 20 multilateral or bilateral and regional international organizations as partners, such as the United Nations Economic and Social Council, the United Nations Educational, Scientific and Cultural Organization (UNESCO), Asian Development Bank, Japan International Cooperation Agency, United Cities and Local Governments (UCLG), and the World Bank, etc., to jointly support the operation and development of the organization.

By creating a knowledge exchange platform and promoting city cooperation and tangible projects, CityNet helps members cope with climate change, disasters, and other challenges, working together towards sustainable urban development. There are four cities in Taiwan that are members of CityNet, including Taipei City, Taichung City, Kaohsiung City, and Taoyuan City. In addition, when the world was heavily impacted by the COVID-19 pandemic in 2020, due to Taiwan's outstanding achievements in epidemic prevention, CityNet organized a series of epidemic prevention online seminars for global members to understand the epidemic situation in the Indo-Pacific region and invited Taoyuan City to share its community epidemic prevention experience at the seminars.

7.4 Non-intergovernmental organization cooperation and exchanges

7.4.1 Industry and corporate organization

1. RE100

RE100 is a 100% renewable energy initiative led by The Climate Group (TCG) and the Carbon Disclosure Project (CDP). It gathers the world's most influential companies to jointly increase the use of green power from the perspective of the power demand. Companies joining RE100 must make a public commitment to achieve 100% renewable energy use between 2020 and 2050 and report the progress of use year by year.

More than 100 companies in Taiwan have joined RE100. Among them, there are ten members headquartered in Taiwan, namely TCI Co., Ltd., Taiwan Semiconductor Manufacturing Co., Ltd., Hair O'right International Corp., 3DL LAB. Inc., and Grape King Bio Ltd., Acer Group, Kingwhale Corp., Delta Electronics Inc., Jola International Co. Ltd., and United Microelectronics Corp., covering industries such as biotechnology, semiconductor manufacturing, cosmetics manufacturing, textile and garment industry, computer and peripheral equipment manufacturing, etc. All of them have set a target year to achieve 100% renewable energy use.

2. EV100

IEV100 is an international electric vehicle

initiative initiated by The Climate Group (TCG) in 2017. It aims to accelerate the low-carbon transformation of transportation through influential companies and related organizations around the world and is committed to making the use of electric vehicles the new normal for enterprises in 2030. All members who join in are required to make a public commitment to achieve at least one of the following items before 2030: (1) self-owned/rental fleet must be electric cars (100% electric for cars under 3.5 tons, at least 50% electric for cars in between 3.5 to 5 tons); (2) install charging facilities for employees and/or customers at all relevant locations; (3) require the use of electric cars in relevant service contracts.

The company in Taiwan currently participating in EV100 is Delta Electronics Inc. It joined EV100 in 2018, hoping to provide its employees and customers with incentives to use electric vehicles through user-friendly and convenient electric vehicle charging stations as well as services to reduce environmental burden. So far, more than 40 electric vehicle charging stations have been installed by the company in its global headquarters, operation bases, and global production bases to support different charging needs. In addition, electric buses are provided as transportation vehicles at the plant site to reduce the carbon emissions from employee transportation

3. EP100

EP100 is an energy productivity improvement initiative initiated by The Climate Group (TCG) and The Alliance to Save Energy (ASE) in 2016. It supports the more efficient use of energy to increase productivity, reduce greenhouse gas emissions, and accelerate the move towards a clean economy. Members are required to make a commitment to achieving at least one of the following three items: (1) increase energy productivity by two times; (2) reduce waste of energy; and (3) use smart energy buildings.

The companies in Taiwan currently participating in EP100 include TCI Co., Ltd. and 3DL LAB. Inc., which pledged to increase energy productivity in 2040 to 35% compared to 2016, and energy productivity in 2048 to 30% compared to 2018, respectively. Among them, TCI Co., Ltd. plans to upgrade and replace its existing equipment and purchase energy-saving as well as highly efficient production equipment for its Pingtung plant in the future. The new construction project of the company at the Panshi Precision and Intelligent Manufacturing Park in Pingtung will receive the ISO50001 energy management system certification, and all the light fixtures in the headquarters will be completely changed to energy-saving LED lights.

4. Climate Action 100+

Climate Action 100+ is a five-year climate action initiative jointly initiated by the Principles for Responsible Investment (PRI) and the four regional climate change investor groups, including the IGCC, Ceres, and AIGCC. It was officially launched on December 12, 2017, as an investor-led participation initiative. When signing the Climate Action 100+ plan, investors pledged to cooperate with at least one of the 167 companies that are important to the transformation to net-zero carbon emissions and seek commitments on key issues of the initiative, such as implementing a strong climate change governance framework, taking actions to reduce greenhouse gas emissions in the supply chain, and strengthening company information disclosure. In addition, the investor website assists investors who have contacted key companies through the Climate Action 100+ to coordinate and manage the initiative.

The participated investment institutions in Taiwan include Cathay Life Insurance Company and Cathay Securities Investment Trust; enterprises include Formosa Petrochemical Corporation, Foxconn Technology Group, and China Steel Corporation. Among them, the Cathay Group joined in 2017 and engaged with the three companies on the list of initiatives. One of them has committed to achieving net-zero carbon emissions in the supply chain by 2050.

5. Science Based Targets Initiative (SBTi)

SBTi was jointly initiated by the Carbon Disclosure Project (CDP), the UN Global Compact (UNGC), the World Resources Institute (WRI), and the World Wide Fund for Nature (WWF). It establishes relevant tools and guidelines for the development of scientific-based goals for companies and provides technical support to assist companies in setting carbon reduction goals. In 2021, it revised upwards the minimum standards for companies to set carbon reduction targets. Starting in July 2022 (starting in 2027 at the latest), companies will set carbon reduction targets on the basis of "controlling the temperature rise to below 1.5°C."

A total of eight companies in Taiwan have made the commitment, including Fubon Financial Holding Co., Ltd., Yuanta Financial Holding Co.,

Ltd., Phihong Technology Co., Ltd., ASE Technology Holding Co., Ltd., Asia Cement Corporation, Sinyi Realty Inc., and FSP Technology Inc. Five companies passed the review, including Delta Electronics Inc., Lite-On Technology Corp., Taiwan Mobile Co., Ltd., Far EasTone Telecom Co., Ltd., and Taiwan Cement Corp., covering the financial industry, cement industry, real estate industry, electronics industry, electronic product manufacturing industry, electronic components industry, and telecommunications industry. Among them, E.SUN Financial Holding Co., Ltd. joined SBTi in 2021 and became the first financial industry in Asia to set carbon reduction targets on the basis of "controlling the temperature rise to below 1.5°C."

6. Task Force on Climate-related Financial Disclosures (TCFD)

The Task Force on Climate-related Financial Disclosures (TCFD) was established by the Financial Stability Board (FSB) in 2015 to develop a set of consistent and voluntary climate-related financial information disclosure recommendations to help investors and decision makers understand the major risks of the organization, enabling them to better assess climate-related risks and opportunities. The recommendations made by the TCFD can be applied to various organizations, including financial institutions, so that information helpful for decision-making and with forward-looking financial impact can be collected. It is more focused on the risks and opportunities involved in the transformation to a low-carbon economy.

As of the end of June 2021, 55 companies participating in TCFD in Taiwan, including 15 in the financial industry, 15 in the information technology industry, two in the shipping industry, three in the traditional industry, one in the telecommunications industry, eight in the materials industry and four in other sectors. Among them, the banking industry participated in TCFD the earliest. The banking industry conforms to the trend of international sustainable finance, follows the spirit of the Principles for Responsible Investment (PRI), Principles for Responsible Banking (PRB), Principles for Sustainable Insurance (PSI), and the Equator Principles, and incorporates environmental and social factors into risk management procedures. The Financial Supervisory Commission of Taiwan also issued the "Green Finance Action Plan 2.0" in August 2020, planning to include TCFD climate-related information disclosure recommendations in the CSR reports or annual reports of listed companies. In addition, in the "information technology" industry, domestic listed companies and benchmarking companies have also responded to TCFD one after another to identify company climate risks and opportunities, and effectively establish evaluation indicators and target management based on the identification results, thereby reducing the financial impact of climate risks on the operation of the company.

In addition, the Financial Supervisory Commission has also formulated the draft guidelines for financial disclosure of climate risks for banks in Taiwan and the draft notes for financial disclosure of climate-related risks in the insurance industry, which are expected to be released before the end of 2021.

7.4.2 Academic and research organizations

1. Industrial Technology Research Institute

The Industrial Technology Research Institute (ITRI) is Taiwan's first non-governmental organization (NGO) observer approved by the United Nations Framework Convention on Climate Change (UNFCCC). Over the years, it has sent representatives to participate in related conferences to keep updated on energy efficiency, renewable energy, smart grid and other low-carbon technologies, and attended various activities of the International Emissions Trading Association as a member of the Association. In addition, it has also joined the Research and Independent Non-governmental Organization (RINGO) of the UNFCCC and has a long-term grasp of the dynamic progress of the UNFCCC issues. During the COP25, it exchanged ideas with Belize and the international community on "Respond to Climate Change: Innovative Low-Carbon Strategies for Green Transformation."

In addition to participating in the Convention, the Industrial Technology Research Institute, as the first member of R&D institutions of the European Association of Research & Technology Organisations (EARTO) outside the European Union, assisted the Association in creating the "RTOs International Network (RIN)." It demonstrated Taiwan's scientific and technological strength to partners in Europe, America, and Asia and helped to solve global problems with innovative technology and industrialization strength, hoping to promote

domestic industries to the World Cup. The Industrial Technology Research Institute will continue to get involved in the international community and work in tandem with RIN members to accelerate the global economic recovery and advance scientific research development.

2. Taiwan Research Institute

Taiwan Research Institute (TRI) has become an observer of the UNFCCC since 2014. It sends representatives to the Conference of the Parties (COP) every year and has several years of experience conducting side events and exhibitions. In 2019, the Taiwan Research Institute attended the COP 25. During the Conference, it participated in the bilateral meetings between the Environmental Protection Administration and the delegations of various countries. TRI representatives exchanged views with Taiwan's diplomatic allies and delegations of various countries on the results of Taiwan's climate change policies and future international cooperation. It also collaborated with the Responding to Climate Change (RTCC), a British climate media organization, to co-organized an exhibition booth to showcase the climate economic model TRICE developed by the TRI and Taiwan's climate policy as well as international cooperation network. In addition, on December 13th, it jointly held an official side event with the German climate policy research think tank on climate change, Energy and Transportation Institute (IKEM), Ecologic Institute, and RTCC to discuss "Carbon Pricing: Concept, Regional Development and Future Governance," exchanging international carbon pricing trend and promotion experience.

3. Taiwan Carbon Capture Storage and Utilization Association

The Taiwan Carbon Capture Storage and Utilization Association (TCCSUA) has promoted the exchange of international carbon storage technologies for many years and the integration of Taiwan's technology with the world. During the COP 24 in 2018, it collaborated with major global carbon capture and storage organizations such as the International Energy Agency (IEA), the CO2GeONet of Europe, and IEAGHG of the UK to share the potential environmental protection contributions of carbon capture and storage. During the COP 25 in 2019, it collaborated with the CO2GeO of Europe to conduct a series of technical seminars in the UK and Japan pavilions. After the Conference, it started the long-term carbon capture technology exchanges between various countries and Taiwan.

7.4.3 Civic groups

1. Delta Electronics Foundation

The Delta Electronics Foundation has actively participated in the UNFCCC COP over the years. The most recent event participated was the side event held in Madrid, Spain, on the first day of the COP 25. It responded to the climate change scientific report released by the "United Nations Intergovernmental Panel on Climate (IPCC)" for oceans, polar regions, and water resources. The foundation's CEO, Mr. Wim Chang, gave a presentation on "Water and Climate Change: Private Sector Engagement and Community Mobilization for Promoting Low-Carbon Development" to share the foundation's experience in implementing water conservation and promoting water resources protection. The foundation also shared with Nigerian NGOs and the international community on how to deal with water issues during the climate crisis.

2. Environmental Quality Protection Foundation

The Environmental Quality Protection Foundation has long been promoting environmental education at home and abroad, focusing on environmental issues such as climate change, climate policy and legal system, water resources conservation, waste treatment, biodiversity, and low-carbon consumption. It regularly participates in the COP and is currently an observer of the "United Nations Framework Convention on Climate Change (UNFCCC)," "Global Environment Facility (GEF)," and a member of the "International Council for Local Environmental Initiatives (ICLEI)."

During the COP 25 in 2019, it co-organized a side event with the Asian-Pacific Resource and Research Centre for Women (ARROW), the Green Club, the Taiwan Youth Climate Coalition (TWYCC), and the International Climate Development Institute (ICDI) to share "Multi-stakeholder Solutions for Community in Asia." At the event, a presentation titled "Indigenous peoples are the guardians and beneficiaries of climate change" was provided to introduce the foundation's engagement in the process of forest restoration and the relevance of Taiwan's indigenous peoples to socio-economic and climate sustainability issues.

3. Mom Loves Taiwan

Mom Loves Taiwan is organized by mothers who care about nuclear power generation issues.

During the COP 25 in 2019, Guatemala and Mom Loves Taiwan jointly organized a side event with the theme, "Guatemala's Actions Towards Achieving the 'Climate Action for Paris Agreement Goals.'" The Ministry of Environment and Natural Resources of Guatemala was invited to give an open remark for the event, sharing the country's voluntary contributions to climate adaptation. Next, Taiwan's International Cooperation and Development Fund (ICDF) presented the "Assistance in the climate adaptation of remote communities and indigenous women in Guatemala" to share ICDF's effort in strengthening the ability of fragile groups in the border areas of Guatemala to adapt to climate change through the Rural Household Sales Guiding Program, the SME Entrepreneurship Coaching and Guiding Program for Capacity Improvement, and the Rural Women Capacity Building and local social development workshops. Mom Loves Taiwan also shared the cases and challenges of assisting disadvantaged groups in Mozambique and Malawi in promoting rural development and food security, fully demonstrating the contribution of Guatemala and Taiwan to climate adaptation and underprivileged groups.

4. Foundation of Taiwan Industry Service and Taiwan Institute for Sustainable Energy

The Foundation of Taiwan Industry Service has been promoting professional guidance on environmental protection and technical consulting services in Taiwan for many years. On the other hand, the Taiwan Institute for Sustainable Energy is focusing on promoting Taiwan's work on sustainability to connect with the world. During the COP 25 in 2019, the two foundations collaborated with Tuvalu, Taiwan's diplomatic ally, to organize a side event jointly. A presentation titled "Plastic Waste Recycling and Fishery Resources Conservation" was provided to assist diplomatic allies and the international community in formulating sustainable development plans for the fishery industry and waste disposal.

5. Taiwan Youth Climate Coalition

The Taiwan Youth Climate Coalition (TWYCC) is Taiwan's most active youth organization participating in the Convention. It has engaged in the COP every year since 2009 and has joined the Youth Non-Governmental Organization (YOUNGO) affiliated with the UNFCCC. In 2012, it established the "Asian Youth Climate Network (AYCN)" with the East Asian Youth. In 2013, the members of the TWYCC were selected as the official contact for the "United Nations Youth Non-Governmental Organization (YOUNGO)" and the Convention Secretariat.

In addition to international participation, the Taiwan Youth Climate Coalition also regularly organizes a series of activities in Taiwan to promote public understanding of international climate governance. In 2020, it organized the "Youth Climate Diplomacy Empowerment Forum" and jointly released the "Citi Youth Climate Empowerment Guide" with Citi (Taiwan) Bank, introducing Taiwan's local climate actions to the international community via English blogs.

References

1. Climate Action 100+: https://www.climateaction100.org/.
2. Website of ICLEI Kaohsiung Capacity Center: http://kcc.iclei.org/tw/.
3. Marshall Islands Home Energy Efficiency and Renewable Energy Loan Program: https://rmi-ee-re.wixsite.com/index.
4. Industrial Technology Research Institute, international cooperation case, ITRI cooperates with world-renowned research institutes to jointly declare the continuous effort in promoting innovative R&D and cooperation: https://www.itri.org.tw/ListStyle.aspx?DisplayStyle=01_content&SiteID=1&MmmID=1036233406747565624&MGID=1126022300724105102.
5. China Steel Corporation, "2020 Corporate Social Responsibility Report," 2020:https://www.csc.com.tw/csc/hr/e/2020/index.html#book5/undefined.
6. Website of Delta Electronics Foundation: https://www.delta-foundation.org.tw/.
7. Website of Ministry of Foreign Affairs, news and announcements for participation in international organizations, the promotion of Taiwan's participation in the "United Nations Framework Convention on Climate Change, the 25th Conference of the Parties (UNFCCC COP 25)": https://subsite.mofa.gov.tw/igo/News_Content.aspx?n=26CC63CC07926BBE&sms=593B53CC099219C4&s=CEDC4C0EB6D4A334.
8. Website of the Global Environmental Education Partnership (GEEP): https://thegeep.org/.

9. Website of the Environmental Protection Administration, Executive Yuan, International Environmental Partnership (IEP): https://www.epa.gov.tw/Page/A1763552876500D0/

10. Website of the Environmental Protection Administration, Executive Yuan, News on Environmental Protection, Taiwan is not absent from the Global Climate Conference - Sharing practical experience on environmental protection actions: https://enews.epa.gov.tw/Page/3B3C62C78849F32F/321c464c-acfb-4e0b-98c3-3f4d8353817b.

11. International Cooperation and Development Fund, "2018 Annual Report of International Cooperation and Development Fund," 2019: https://www.icdf.org.tw/2018Chinese/2018-ch.html.

12. International Cooperation and Development Fund, "2019 Annual Report of International Cooperation and Development Fund," 2020: https://www.icdf.org.tw/2019Chinese/2019-ch.html.

13. International Cooperation and Development Fund, "2020 Annual Report of International Cooperation and Development Fund," 2021: https://www.icdf.org.tw/2020Chinese/index.html.

14. Website of the International Cooperation and Development Fund: https://www.icdf.org.tw/.

15. Website of the International Environmental Partnership: https://www.iep-global.org/.

16. Website of the IDB Industrial Sustainable Development Clearinghouse: https://proj.ftis.org.tw/isdn/.

Chapter 8

Chapter 8 Education, Training and Communication with the Public

8.1 Education

8.2 Training

8.3 Social dialogue and public communication

Chapter 8 Education, Training and Communication with the Public

The ministries and councils of the government in Taiwan handle climate change education, talent training, and public communication programs in accordance with their respective authority and responsibilities, working in concert with the requirements of Article 6 of the United Nations Framework Convention on Climate Change for promoting climate change education, training, and public awareness. Therefore, this chapter is divided into three sections, namely "Education," "Training," and "Public Communication," to introduce respectively the incorporation of climate change into the education system of Taiwan, the training of climate mitigation and adaptation-related talents, and the collaboration in climate actions cooperation, as well as the implementation results.

8.1 Education

According to Article 8, Paragraph 2, Subparagraph 16 of the Greenhouse Gas Reduction and Management Act: The Ministry of Education, the Environmental Protection Administration, and the Bureau of Energy of the Ministry of Economic Affairs are the co-organizers for the education and advocacy of climate change adaptation and greenhouse gas reduction. In addition, according to the "Adaptation Strategy to Climate Change in Taiwan" and the "National Adaptation Action Plan to Climate Change" approved by the Executive Yuan, the Ministry of Education is responsible for enhancing the awareness and skills of climate change and cultivating talents to cope with climate change. To comply with the national policy and achieve the goal of cultivating climate change-related talents, projects related to climate change education promotion were planned and conducted.

In 2020, the "Strategy Map for the Climate Change Education Promotion Program of the Ministry of Education (2021-2023)" was formulated to establish the promotion direction for the next three years and set "Accelerating Climate Actions Comprehensively in Response to the Climate Emergency" as the vision of the Program. It also helps to develop tasks, understand climate change, implement climate actions, launch innovative services, and cultivate climate resilience as well as core values: correct cognition, cross-disciplinary learning, action skills, a link between learning and application, innovation excellence, international connection, and four thematic strategies, including incorporating sustainable development education into mainstream teaching, promoting cross-disciplinary teaching to build innovative and practical skills, implementing climate actions to promote the link between learning and application, and strengthening the international connection to engage in international actions and other detailed plans. In addition, a climate change educational information platform has been established to provide teaching materials for promoting climate change education in primary and secondary schools as well as in colleges and universities. A career development handbook on climate change-related fields was planned to guide students in thinking about their future studies from the perspective of climate change. Moreover, implementation goals, strategies, and action plans are adjusted on a rolling basis according to the latest development of trends at home and abroad, as well as the results and tasks of previous projects conducted.

Climate change education is divided into two major directions: climate change mitigation education and climate change adaptation education: in mitigation education, campus carbon inventory is promoted, allowing students to understand the greenhouse gas emissions generated by school activities and further propose mitigation plans. With regards to strengthening industry-university linkages, government-industry-university-institute collaboration in mitigation and energy technologies is conducted to increase students' opportunities for practical participation.

As to adaptation education, campus adaptation actions are promoted. Schools may guide students to carry out adaptation actions in priority based on the climate and environmental characteristics of their geographical locations and in conjunction with living labs or cross-disciplinary teaching methods. In addition, the industry-university linkage is established through government-industry-university-institute collaboration in climate services.

Due to the difference in school education, learning is divided into two stages; general education and professional education. General education is aimed at students in high schools or under, combined with the 12-Year Basic Education and the environmental education guidance groups in counties and cities to improve the students' literacy on climate change, expand and activate the teaching alliance by including teachers in high schools and under to join the "12-Year National Education Teaching Alliance," establish a cross educational system climate change teaching support platform, provide learning and exchange for teachers and students with the cross educational system, and integrate with the climate change teaching resources for the cross educational system, creating a synergistic effect.

On the other hand, professional education cultivates climate change professionals in colleges and universities. It is committed to incorporating teaching materials into textbooks to reinforce Taiwan's climate change teaching materials, promoting climate actions through the implementation of cross-disciplinary education and living labs to enhance students' climate action capabilities. As to industry-university linkage, based on the network of various professional fields, government-industry-university-institute collaboration is conducted to establish an exchange mechanism with enterprises or the government, allowing the industry or the government to issue questions and the schools to solve the questions so that more specific exchanges between the industry and universities can be carried out. Furthermore, a climate change creative implementation competition is held to demonstrate the practical skills of university students in climate change, effectively combining theory and practice.

The following section introduces Taiwan's climate talent cultivation strategies in terms of "general education" and "professional education," as well as the current status of energy education in Taiwan.

8.1.1 Climate change education

1.12-Year Basic Education

The promotion of climate change general education is mainly based on the 12-Year Basic Education. The 12-Year Basic Education of Taiwan includes six years of elementary school education, three years of junior high school education, three years of senior high school education, and four years of university education. Taiwan's Curriculum Guidelines of 12-Year Basic Education were officially implemented in 2019. These Guidelines have been in preparation since 2007. After years of planning and discussion, they have become the most important guiding principle for Taiwan's elementary school, junior high school, and senior high school education.

In the "Curriculum Guidelines of 12-Year Basic Education," 19 topics are clearly defined, acting as the structure and connotation for establishing a national knowledge system, which includes several climate change-related issues in "environmental education," "energy education," "disaster prevention education." The connotations of these issues are as follows: (**Table 8.1-1)**

Table 8.1-1: Climate change related issues and their connotations in the 12-Year Basic Education of Taiwan

Issue	Learning objectives
Environmental education	Recognize and understand the environmental crises and challenges faced by human survival and development; explore climate change, resource depletion, and biodiversity loss, as well as social and environmental injustice; consider the significance of personal development, national development, and human development; implement green, simple and sustainable living.
Energy education	Promote basic concepts of energy; develop correct energy values; cultivate energy-saving thinking, habits, and attitudes.
Disaster prevention education	Understand the causes of natural disasters; develop disaster risk management and disaster prevention and rescue capabilities; strengthen the responsibility, attitude, and practice of disaster prevention and rescue operations.

Source: National Academy for Educational Research, "Issue Integration Instruction Handbook," 2017

The design concept of the 19 issues is to strengthen the connection between education and society. Schools or teachers can integrate various issues into the school curriculum in accordance with the needs of students and schools, encouraging students to develop analytically, thinking, and cross-disciplinary problem-solving skills from different fields and topics. For the three educational stages of elementary school, junior high school, and senior high school, the National Academy for Educational Research has also defined the "Substantive Connotation" of various issues appropriate for students' level, helping students to gradually understand important contemporary issues such as climate change.

Taking the issue of "environmental education" as an example, the connotation of knowledge must include five learning themes: environmental ethics, sustainable development, climate change, disaster prevention and rescue, and sustainable utilization of energy and resources. As to the environmental challenges faced by mankind in response to climate change, the connotations include global warming and its induced changes in climate patterns, as well as the impact and effect on humanity. From the awareness of climate change through daily life, one can understand the causes and effects of climate change and practice climate change mitigation and adaptation in life. The educational stage of elementary school focuses on the awareness of climate change's impact on life, and the educational stage of junior high school focuses on understanding the concepts of the greenhouse effect and climate change, the resilience and vulnerability of climate change, as well as the policies related to climate change, while the educational stage of senior high school puts emphasis on the international development of climate change, the exploration of international conventions and the participation in regional climate change actions.

2. Promotion of climate change education in elementary and junior high schools

(1) Teaching materials

To promote teachers' understanding of climate change as well as climate change education at all stages, establish systematic thinking on climate change education, integrate with international sustainable development education, and allow participating school representatives and teachers to be capable of planning school-based curriculum, comprehensive activity curriculum and club curriculum for climate change education, the "Promoting Climate Change Education Empowerment and Lesson Plan Workshop for Elementary and Junior High Schools" was conducted, guiding teachers to use climate change education (CCE) and education for sustainable development (ESD) as the main body for designing lesson plan modules and making the content of the lesson plan modules to conform to the connotations of the 12-Year

Basic Education. To work in concert with the implementation of the Curriculum Guidelines of 12-Year Basic Education and encourage teachers in high schools and under to actively participate in the creation of climate change featured courses and elective courses, a national climate change education teaching module competition for elementary and junior high schools was organized to select excellent teaching modules, serving as the examples for promoting climate change education in elementary and junior high schools, and guiding schools at all levels to take climate change as the subject for special and elective courses.

To assist the development of a school-based curriculum on climate change, pioneering schools are selected to encourage elementary and junior high schools in Taiwan to actively promote climate change education and develop a school-based curriculum for climate change education by using the school and regional characteristics. The curriculum developed can be promoted to and used by other schools, and serve as a reference for developing the "teaching module that combines climate change education and education for sustainable development (CCESDG = CCE + ESD + SDG)."

Currently, 48 sets of teaching materials on climate change adaptation have been produced for elementary schools, junior high schools, and senior high schools, guiding teachers to take climate change education (CCE) and education for sustainable development (ESD) as the main body for designing lesson plan modules that are in line with the connotation of the 12-Year Basic Education. In addition, 36 climate change teaching materials that are in line with the 12-Year Basic Education for elementary and junior high schools were produced, more than 30 sets of climate change lesson plan modules for elementary and junior high schools were produced, and one "Popular Science Teaching Material Production for Senior High School Students" was completed. The above-mentioned teaching materials and lesson plans can be downloaded from the "Climate Change Education" website.

(2) Incentive measures

The Ministry of Education has promoted the teaching concept of "living laboratory" while integrating climate change with the 12-Year Basic Education to enhance instructional effectiveness. The "living laboratory" emphasizes the use of students' living environment as the education site to carry out continuous research and innovation, gaining knowledge while solving life problems, and developing independent thinking skills.

The concept of "living laboratory" was proposed by Professor William Mitchell of the Massachusetts Institute of Technology (MIT). When the concept is applied to Taiwan's climate change education, it is divided into lower, intermediate, and upper levels. The lower level corresponds to elementary schools, focusing on detecting climate change and developing adaptation strategies. The intermediate level corresponds to junior high schools. In addition to detecting and proposing strategies, students are also required to learn relevant knowledge. The upper level corresponds to senior high schools. After identifying the impact of climate change, it is necessary to guide students to independently collect data, propose hypotheses and predictions after finding possible factors, take actions, and modify factors as well as models based on the results.

In order to encourage elementary and junior high schools to practice "living laboratory," the Ministry of Education selected three schools in 2010 as the "pioneering schools for climate change education in elementary and junior high schools." National Taiwan Normal University provided guidance to students and teachers to use the teaching resources on the "Climate Change Education website" to develop teaching materials and educational activities that are tailored to local conditions and in line with the United Nations Sustainable Development Goals. The results are provided and promoted to other schools, serving as references to help other schools develop teaching materials and educational activities.

3. Strengthening the promotion of climate change education in colleges and universities

(1) Teaching alliance and seeded teacher training

The "Climate Change Education Teaching Alliance Program" is promoted to conduct professional knowledge discussions

and diversified exchanges on nine major areas of climate change (health, land use, disasters, energy supply and industry, water resources, agricultural production, coastal areas, infrastructure-transportation systems, and biodiversity), hoping to cultivate more climate change related talents. In addition, the professional background and area of expertise of teachers in various colleges and universities are evaluated to continuously invite teachers who are interested in the Program to form a "Climate Change Teaching Alliance," enhancing teachers' teaching capacity and exchange experience to promote climate change education.

(2) Subsidies for educational activities and production of teaching materials

To provide college and university students the opportunity to learn about climate change-

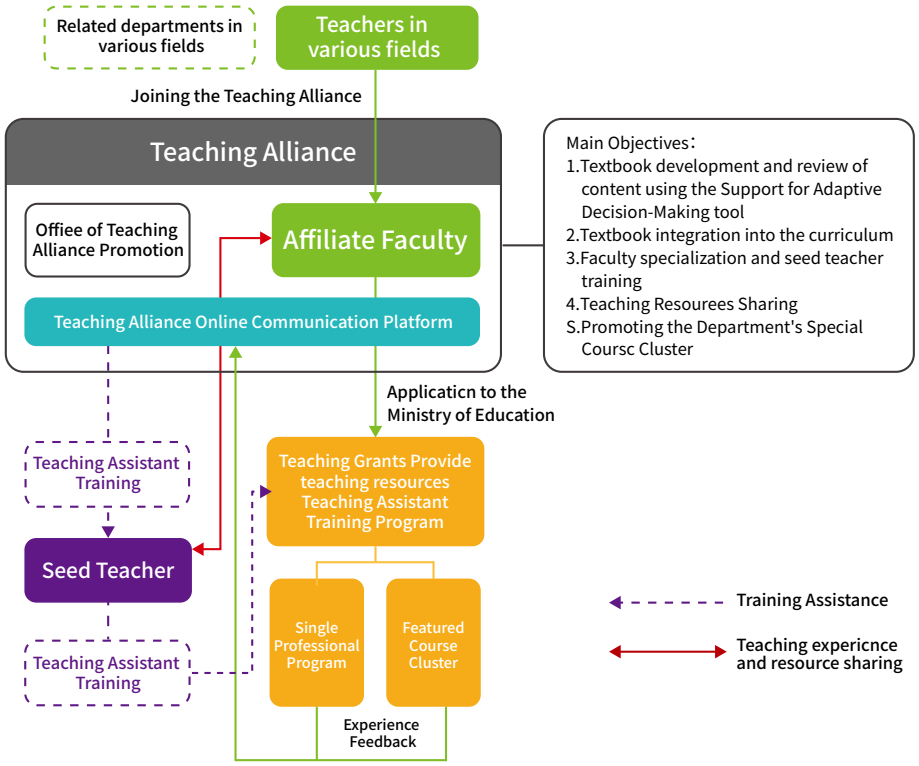

Figure 8.1.1-1: Operation of Climate Change Adaptation Education Teaching Alliance

Source: Climate Change Education website

related issues, climate change educational activities held in colleges and universities are supported. In addition, the national climate change adaptation policy is implemented to promote the cultivation of climate change professionals and encourage colleges and universities to propose climate change-related or cross-disciplinary curricula and develop professional supplementary teaching materials or related educational activities to improve students' climate change literacy and capability, cultivating talents with climate change knowledge.

In addition to offering subsidies to courses, the Ministry of Education also compiles climate change teaching materials applicable to various fields for teachers to use. Currently, there are seven core modules and nine professional modules in the climate change teaching materials for general courses in colleges and universities, with a total of 16 modules. As to the professional climate change teaching materials for colleges and universities, the professional courses in nine major fields are integrated into nine sets of supplementary teaching materials and nine sets of practice teaching materials, with a total of 18 sets of teaching materials. The cross-disciplinary teaching implementation guide and the living

Figure 8.1.1-2: The 4th SDGs Ecological Urban-Rural Planning and Practice Workshop

Source: Ministry of Education

laboratory promotion (implementation) guide were completed, one copy for each team in the north and south regions. One set of "audio-visual teaching materials for the case of international environmental action" was completed. The "cross-disciplinary teaching material module design" for the nine major fields converted professional teaching materials in various fields into modules. The compilation of simplified English teaching materials was completed. The above-mentioned information can be downloaded from the "Climate Change Education" website.

(3) Cross-disciplinary teaching

Cross-disciplinary teaching and practical skills build climate action capacity. Cross-disciplinary teaching focuses on the exchange of students or teachers in different fields. In recent years, through conducting various cross-disciplinary activities, such as creative competitions, course subsidies, symposiums, workshops, micro-lectures, and exchange activities, students or teachers in different fields had a better understanding of other fields and a clear grasp of the cross-disciplinary concept, stimulating participants to subtly incorporate cross-disciplinary thinking and reflect it in learning or teaching.

(4) Living laboratory

The concept of "living laboratory" was proposed by Professor William Mitchell of the Massachusetts Institute of Technology (MIT). When the concept is applied to Taiwan's climate change education, it emphasizes the use of students' living environment as the education site to carry out continuous research and innovation, gaining knowledge while solving life problems, and developing independent thinking skills.

Figure 8.1.1-3: Living laboratory "Irrigation and Drainage Engineering" course for teaching alliance in water resources

Source: Ministry of Education

Taking school as the living laboratory, based on the "Whole-Institute Approach," climate actions of students are implemented through the promotion of action learning. It can be called a green school for elementary and junior high schools and a "green university" or sustainable campus or campus living laboratory for colleges and universities.

(5) Climate Change Innovation Competition

In recent years, the Ministry of Education has actively promoted education projects related to climate change. In addition to cultivating students' understanding of climate change issues, it is hoped that these projects can stimulate college and university students' creativity in climate change adaptation. After reinforcing the theoretical knowledge, it is also hoped that practices can be carried out to deepen the understanding and practical skills of college and university students on climate change adaptation. Since 2016, the "Climate Change Innovation Competition" and related empowerment camps have been planned and organized for colleges and universities, allowing college and university students to participate in climate change issues, develop their creativity, find solutions to climate change problems, and implement innovative ideas. Any forms of innovative work are not acceptable, and the participating students are encouraged to make positive "changes" with positive climate actions, make good use of creativity and cross-disciplinary thinking, and create more possibilities and opportunities for sustainable development. The themes of the final award-winning works cover education, urban planning, architecture, urban farms, aquaculture, product design, etc., reflecting the diverse nature of climate change issues and earning recognition from the review committee with fruitful results.

Figure 8.1.1-4: "The Perspective," Gold Award in the Climate Change Innovation Competition

Source: Ministry of Education

8.1.2 Climate change adaptation education

The cultivation of climate change professionals in Taiwan is mainly based on the "Climate Change Teaching Alliance." The main purpose of the operation is to help teachers in colleges and universities promote knowledge education on climate change adaptation, assist in the integration with the industry, and cultivate professionals in climate change adaptation. After the teachers of colleges and universities join the alliance, they can receive subsidies for teaching resources from the online exchange platform, including teaching materials, teaching assistant training courses, and experience from seeded teachers, as shown in the upper part of Figure 8.1.1.

As shown in the lower part of Figure 8.1-1, after receiving the teaching materials from the alliance, teachers can offer a "single specialized curriculum" that can be completed in one semester or arrange a series of cross-semester "featured curriculum groups" with increasing difficulties, according to the needs of the department. The curriculum starts from the major of the department, and combines the professional textbooks used by the department with the "Professional Supplementary Teaching Materials" and the "Professional Practice Teaching Materials"

provided by the alliance, so that students can not only cultivate their professional skills but also understand the connection between their majors and climate change, which is different from the "general" education that focuses on basic concepts as described in the previous section.

Taking the "health field" of the "Adaptation Strategy to Climate Change in Taiwan" as an example, the "Climate Change Teaching Alliance" reviewed the community health nursing textbooks currently used by the nursing department, analyzed the parts related to climate change adaptation, and compiled the "Professional Practice Teaching Materials for Climate Change and Health Adaptation," which has become a compulsory subject for the department. It is expected that the teaching materials will be directly and indirectly used by the department of nursing of 30 colleges and universities across the country.

Currently, the alliance has completed nine "Professional Supplementary Teaching Materials" and nine "Professional Practice Teaching Materials." In addition to continuously developing the teaching materials for other fields, feedback from teachers of the Alliance was also received during the teaching process for further improvement.

8.1.3 Energy education

In accordance with the provisions of Article 23 of the "Basic Environment Act," the promotion of the Energy White Paper, as well as relevant laws and policies, the Ministry of Education has incorporated energy education issues into the official curriculum for implementation and included them among the 19 topics in the Curriculum Guidelines of 12-Year Basic Education (Curriculum Guidelines), setting the topics and substantive content of the issues related to energy education.

Through the compilation of supplementary materials related to energy education, students can understand the positive and negative impacts of energy on the environment and economy, as well as its values through the existing education system, and incorporate it into the important policy connotations of national green energy development and energy transformation, so as to implement the learning and practice of sustainable utilization of energy and resources, and train students to become citizens with independent thinking.

In addition, the Ministry of Education also cooperates with the Executive Yuan's "Green Energy Technology Industry Promotion Plan" to promote the "Clean Energy System Integration and Application Talent Cultivation Plan," focusing on the cultivation of energy technology talents in colleges and universities, and on the other hand, taking root in the experience and learning of energy technology, energy-saving and carbon reduction for elementary and junior high schools. Through curriculum modules, creative implementation, and industry-university integration strategies, students are trained in energy innovation, professional technology, actual practice, and system integration capabilities so as to nurture the professionals needed to promote energy technology research and industrial development in Taiwan.

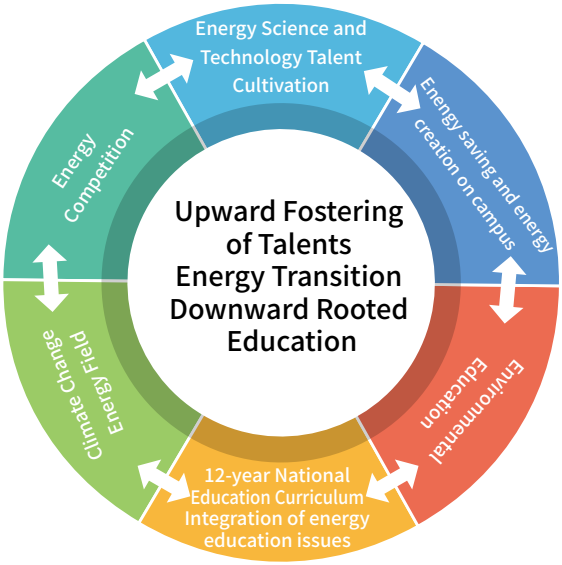

Figure 8.1.3-1: Education Promotion Framework of the Ministry of Education

Source: Energy Education Resource Center website

8.2 Training

Considering the fact that future climate change impacts are not limited to specific sectors and occupations, the training of climate change professionals is promoted in Taiwan, which is conducted by the competent authorities of various sectors according to the special needs of each occupation. The following is an introduction to the training measures, in terms of "mitigation" and "adaptation," currently being implemented in Taiwan.

8.2.1 Climate mitigation related talents

The "Greenhouse Gas and Reduction Management Act" and the "National Greenhouse Reduction Action Plan" of Taiwan not only divide the greenhouse gas reduction strategies of various industries according to the six major sectors (energy sector, manufacturing sector, transportation sector, residential and commercial sector, agricultural sector and the environmental sector), but also require the six major sectors to conduct mitigation-related training activities. The following examples illustrate the mitigation-related talent training measures carried out by the six major sectors.

1. Energy sector

In order to improve the management strategy and mechanism of greenhouse gas reduction for the energy industry, the Bureau of Energy, Ministry of Economic Affairs has been assisting and guiding the energy industry in carrying out greenhouse gas reduction declaration, inventory, registration, query platform operation, and offset projects since 2005. To strengthen the climate change mitigation capacity of the energy industry and enhance industrial competitiveness, the Bureau of Energy, Ministry of Economic Affairs conducts the "Energy Industry Greenhouse Gas and Carbon Reduction Management Professional Training" program. The program aims to offer training to private consultancies, Energy Service Company (ESCO), and other organizations or individuals interested in climate mitigation training courses.

2. Manufacturing sector

To promote energy saving and carbon reduction technical guidance to various industries and reduce the intensity of greenhouse gas emissions, the Industrial Development Bureau, Ministry of Economic Affairs has promoted energy saving management and related training courses for small and medium-sized enterprises. A total of 160 people have completed the training and received qualification certificates. The Ministry of Science and Technology also provides climate-related training programs for those who are interested. The program consists of regular training courses and short-term technical training courses or seminars. About 15 training courses are expected to be held each year. It is estimated that the program can provide training to 500 people each year.

3. Transportation sector

To promote a green transportation system, the Ministry of Transportation and Communications has implemented the "Knowledge Building and Promotion of Green Transportation" and the "Green Transportation System Promotion Website" from 2012 to 2020 based on short- and medium-term goals. The current achievement is establishing the Low-Carbon City Promotion Office in Taichung City. The low-carbon transportation promotion plan includes strengthening the bicycle road networks, promoting green transportation vehicles, creating a safe transportation environment, completing the mass rapid transit system, building a smart transportation system, and accelerating the replacement of old buses as well as the two-cycle engine scooters.

4. Residential and commercial sector

In the residential sector, the Environmental Protection Administration, Executive Yuan has focused on subsidizing local governments to implement low-carbon homeland building and other related projects, which specify that local governments shall conduct climate change training and promotion for outstanding villages, to spread the implementation results of the "Low-Carbon Sustainable Homeland Rating Promotion Project." As for the commercial sector, the Department of Commerce, Ministry of Economic Affairs has worked with local governments to promote local commercial settlements or shopping malls to carry out independent energy saving and carbon reduction and to guide enterprises in energy-saving planning and using energy-saving financial analysis system.

5. Agricultural sector

To face the new environmental challenges of global warming and climate change, the Council of Agriculture, Executive Yuan, has continued to promote the "Guidelines for the Planning, Design, Supervision and Management of Applying Ecological Methods in Farmland Water Conservancy Construction" since 2014. In addition, to further promote ecological engineering and implement energy conservation as well as carbon reduction policies, the Council of Agriculture continued to maintain and update the energy-saving and carbon-reduction assessment system for the farmland water canal project and conducted advanced training courses for seeded guides from various irrigation associations since 2016.

6. Environmental sector

To enhance the climate change professional knowledge of environmental educators, the Environmental Professionals Training Institute of the Environmental Protection Administration, Executive Yuan launched the "Core Subjects and Professional Fields 120-hour Training Framework for Environmental Educator" in 2015 and published training materials for the professional field of climate change, covering topics such as climate change mitigation and adaptation, greenhouse gas emission trends and strategies, carbon tax and carbon market, product carbon footprint assessment, and application of environmental footprint quantification tools.

8.2.2 Talents related to climate adaptation

In the latest "National Climate Change Adaptation Action Plan," in addition to categorizing climate change adaptation plans according to the eight major areas of disasters, life-supporting infrastructure, water resources, land use, coastal area, energy supply and industry, agricultural production, and biodiversity, and health, the responsible ministries and councils (or committees) are also required to conduct adaptation-related manpower training. The following examples illustrate the manpower training in the eight major areas for climate change mitigation.

1. Disasters

In order to build a disaster risk map for Taiwan and for each county or city under different disaster scenarios, the Ministry of Science and Technology has implemented the "Taiwan Climate Change Projection Information and Adaptation Knowledge Platform (TCCIP)" (see Chapter 6 for details). The Water Resources Agency implemented flood prevention and rescue plans and promoted the concept of "All People Disaster Prevention" as well as independent flood prevention communities in various counties and cities across Taiwan, recruited and trained volunteers to reinforce disaster prevention and emergency response capability for all people. In order to strengthen the conservation and management plan of the reservoir catchment area, the Water Resources Agency conducted remediation, soil and water disaster early warning and response, and sand control survey and review for the reservoir catchment area in 2019. In response to the impact of the increasing frequency of extreme weather on the archaeological cultural relics, the Bureau of Cultural Heritage conducted the cultural asset-related adaptation training in 2019. In response to the potential impact of natural disasters on the traditional aboriginal territories, the Council of Indigenous Peoples promoted the project for protecting traditional heritage sites and ecological resources in the aboriginal villages in 2019.

2. Life-supporting infrastructure

In response to the impact of climate change on railway safety, the Taiwan Railways Administration, Ministry of Transportation and Communications has approved the railway slope maintenance handbook, strengthened the training and management of management personnel, and reduced the damage potential and hazard of railway slopes. The government supported telecommunications operators to build fixed-point and mobile communication platforms for disaster prevention and rescue. It incorporated the concept of adaptation into training and practical exercises to improve the survival rate of the equipment, such as base stations and satellite transmission devices, after disasters.

3. Water resources

In response to the impact of future climate change on the utilization of agricultural water resources, the Council of Agriculture, Executive Yuan promoted the renovation and improvement of farmland water conservancy facilities and strengthened management and maintenance of irrigation water quality. In addition, trainings were conducted to enhance agricultural practitioners' climate change adaptive capacity. Furthermore, in response to the impact of future climate change on industrial water use, the Water Resources Agency, Ministry of Economic Affairs has promoted the Industrial Water Use Guidance and Water-saving Plan and implemented it simultaneously in the northern, central, and southern regions of Taiwan. A total of 1,069 major water users have been provided with the consulting services. After the consultation, the total water saving potential reached 21,511 tons/day. Water-saving incentives were also provided to strengthen the climate change the adaptive capacity of industrial practitioners.

4. Land use

To effectively adopt adaptation strategies to reduce land-use vulnerability, land use planning and land conservation are effective management methods to deal with the impact of climate change. The Ministry of the Interior, together with the Council of Agriculture and the Ministry of Economic Affairs, formulated an urban and national park plan according to the current domestic spatial structure. In the medium-term national park plan, the cultivation of conservation scientists is planned to cover the research fields of ecology, animals and plants, forests, wetlands, and oceans. The research sites for long-term investigation and monitoring by conservation scientists are also provided. Professional practitioners in cross-disciplinary management of national parks such as humanities, geology, landscape, recreation, environmental education, nature conservation, and engineering are cultivated.

5. Coastal area and ocean

To strengthen the training of Taiwan's talents in the environmental service system for marine weather and meteorological disaster prevention, the Central Weather Bureau held the "Seminar on Environmental Information Platform Application for Marine Weather Disaster Prevention" in 2019, inviting a total of 58 disaster prevention agencies as well as research teams from industries, the government and universities to jointly promote meteorological disaster prevention and related information. In addition, the Central Weather Bureau also cooperated with the National Severe Storm Laboratory (NSSL), a subsidiary of the National Oceanic and Atmospheric Administration (NOAA), to conduct talent training activities, and introduce automatic timely forecasting systems, autonomous radar data processing as well as R&D talents.

6. Energy supply and industry

From 2012 to 2021, the Bureau of Energy, Ministry of Economic Affairs conducted training for climate change adaptation professionals for the energy industry, studied the latest development in climate change adaptation issues, and issued the "Bi-Weekly Report on Climate Change Adaptation for the Energy Sector" every two weeks, serving as a reference for the public. From 2014 to 2018, the Industrial Development Bureau, Ministry of Economic Affairs organized the "Manufacturing Industry Climate Change Adaptation Publicity and Briefing." Furthermore, through the "Manufacturing Industry Climate Change Adaptation Demonstration Project" and the "Manufacturing Industry Climate Change Adaptation Guidelines and Assessment Tools," assistance was provided to help manufacturers cultivate professionals in climate change adaptation management and risk assessment. From 2013 to 2018, the Small and Medium Enterprise Administration (SMEA), Ministry of Economic Affairs, conducted the "Corporate Climate Change Adaptation Seminar." In 2019, the SMEA organized the "Seminar on Climate Change Adaptation and Climate Insurance Development Trend" to train practitioners from the technical service as well as the manufacturing industry.

7. Agricultural production and biodiversity

To reduce the impact of climate change on agricultural production, the Council of Agriculture, Executive Yuan, continued to promote measures such as robust greenhouse facilities, crop damage and hazard management systems, and agricultural insurance. It also provided training for professionals in agricultural climate change adaptation. Currently, through industry-university collaboration, teaching material promotion, corporate lectures, and seminars, agricultural adaptive capacity and innovation are improved. Since 2019, the Council of Agriculture, Executive Yuan has launched the activity of eating at least one meal of organic vegetables per week for school lunches in Taipei City to strengthen students' understanding of organic agriculture, environmental education, and food and agricultural education. The Environmental Protection Administration, Executive Yuan, has called for catering businesses to participate in the campaign of becoming cherish-food shops, and more than 80 restaurants have joined the campaign to reduce the impact of food production on climate change from the consumer side.

8. Health

To avoid occupational injuries caused by workers working outdoors under high temperatures, the Ministry of Labor has organized the "High-Temperature Outdoor Operation Hazard Prevention Publicity" since 2019 to strengthen employers' and workers' awareness of occupational safety brought about by the extremely high temperature crises in the future. Furthermore, aiming at the correlation

between extremely high temperature events and occupational safety under climate change, the "Study on the Impact of Climate Change on the Thermal Stress and Physical Load of the Construction Industry" was completed.

9. Capacity building

The Financial Supervisory Commission continues to urge the Taiwan Academy of Banking and Finance to plan and arrange relevant training courses and seminars, invite domestic and foreign experts to share and exchange experience, develop a green project financing model suitable for Taiwan, and enrich the local project financing and lending capacity. Relevant training courses and seminars include: "Offshore Wind Power Financing Risk Seminar," "Forum on the Impact of Promoting the Equator Principles on the Financing Business Opportunities and Challenges for the Solar Photovoltaic Industry," "Renewable Energy Project Financing Talent Training Seminar," "Leading Executive Apex Program (LEAP) - Green Finance Innovation Trend," "Corporate Governance Lectures - ESG and Sustainable Governance; the Advancement and Retreat of the Financial Industry under Climate Change," "Climate Change Risk Management Workshop" and "Climate Change Risk Management Workshop" and "ESG Model Development and Credit Risk Workshop."

In 2018, the Taiwan Academy of Banking and Finance held a total of 45 training sessions with 2,327 participants. In 2019, it held a total of 25 training sessions with 1,109 participants. In 2020, it held a total of 15 training sessions with 422 participants and organized the "2020 Green Finance New Era Summit Forum," with a total of 239 participants. It also held five financial knowledge tour activities and financial knowledge fun learning lectures for the general public, with a total of 290 participants. As of June 2021, the Taiwan Academy of Banking and Finance has held four sessions, with a total of 196 people participating in the training.

8.3 Social dialogue and public communication

The response to climate change relies on the joint effort of the government and the public. Through the implementation of public communication, the formulation of policies can be improved. Through public-private cooperative initiatives, climate empowerment can be promoted to jointly create a sustainable environment. The following introduces the social dialogue and public participation in Taiwan's climate and energy policies, as well as the actions carried out by civil society organizations in promoting climate empowerment.

8.3.1 Social dialogue and public participation in climate and energy policies

Taiwan has established a complete public participation mechanism during the policy implementation stage. In addition to holding expert consultations and public hearings as required by laws and regulations, live broadcasts and symposiums are also used to expand and deepen social communication. In recent years, the public participation mechanism has been gradually introduced in the policy planning stage. For example, the Net-Zero Pathway Task Force has been launched to gather all sectors of the community to discuss key technologies or issues of net-zero emissions and the formulation of the Energy White Paper. By expanding public participation and planning future energy policies, as well as establishing the "climate talks.tw" platform, interactive policy information and online consultation are provided. Through work circles, large-scale seminars, etc., collaboration with representative groups on specific issues is carried out to jointly formulate policies. Moreover, consultation with the public's opinions is also conducted to improve the overall policy planning.

1. Net-Zero Pathway Task Force

In response to the international trend of promoting net-zero emissions of greenhouse gases by 2050, the Office of Energy and Carbon Reduction, Executive Yuan, officially launched the net-zero emission pathway assessment in December 2020.

In order to incorporate public opinions in the planning stage, a vision group was specially set up to start a half-year social dialogue from March to August 2021, planning the vision of Taiwan's net-zero transformation. Regarding various key technologies or issues needed to promote net-zero emissions, covering carbon-negative emission technologies, carbon-free energy, net-zero buildings, green

transportation, low-carbon industries, economic tools, and just transition, all walks of life were invited to participate in dialogue through workshops. The participants include competent authorities of related businesses, experts and scholars in various fields, important industry associations, and civic groups, summing up to a total of 110 non-governmental representatives.

Figure 8.3.1-1: "Net-Zero Pathway Task Force" Social Vision Dialogue

Source: Environmental Protection Administration, Executive Yuan

2. Energy White Paper

The amendment to the "Energy Development Guidelines" approved in April 2017 listed the "Energy White Paper" as the mechanism for implementation. The Bureau of Energy, Ministry of Economic Affairs promotes the collaborative output mechanism between the government and the private sector and invites experts in various fields and the public to participate in policy formulation through preparatory meetings, working groups, consensus conferences, focus meetings, and online consultations.

The first stage is to collect public concerns and inventory of existing measures, serving as the basis for the draft White Paper and the discussion in the next stage. In 2017, preparatory meetings were held in Taiwan's northern, central, southern, and eastern regions, inviting the public and civic groups for a discussion. A total of 617 people participated, and 605 pieces of opinions were collected. At the same time, 174 energy policies and promoted measures were checked. The existing measures and public opinions were then organized to propose 21 "key plans (projects)," of which 19 were developed from existing policies, and two were derived from public opinions.

In the second stage, five working groups in different fields were established, including energy governance, energy conservation, electricity, new and renewable energy, and green energy technology industries, to develop specific content for key plans. Each working group consists of 12 members, including scholars with energy expertise, and representatives from the government, industrial research institutions, and the public, who work jointly to produce a draft of various "key plans (projects)" in the "Energy White Paper." After the draft was completed in July 2018, it was published online for the public to view and make any comments.

In the third stage, to gain an in-depth understanding of the public's criticism and suggestions about the draft, focus meetings,

consensus conferences, and online consultations were held in 2018, as shown in Figure 8.3.1-2. Focus meetings were theme-oriented; industry, academic research, and civic groups were invited to discuss and fully communicate. Consensus conferences were conducted through sampling; citizens qualified to represent Taiwan were selected as representatives based on the national population and the registration status, and discussions on the key draft plans of the White Paper were carried out. In addition to the above mechanisms, the public can also use the "Online Participation in Public Policy Platform" of the National Development Council to freely express their opinions about the draft. After the public opinions were collected and compiled, they served as a reference for the five working groups to revise the "Energy White Paper," which was finally approved by the Executive Yuan in November 2020, setting a model for Taiwan's energy policy through the joint efforts of all walks of life, and pushing the government to continuously move forward towards the goal of energy transformation.

Figure 8.3.1-2: "Energy White Paper" citizen engagement workshop in the third stage

Source: Website of the Bureau of Energy, Ministry of Economic Affairs

3. "Climate talks.tw" platform

The Environmental Protection Administration, Executive Yuan, established the "climate talks.tw" platform in 2020. The visualized and interactive interface presents various sectors' greenhouse gas reduction data and the progress of implementing greenhouse gas reduction measures. It also organizes essential domestic and foreign climate policy information and the related websites of various ministries and councils (or committees) so that users can quickly grasp the climate policies implemented in Taiwan. In addition, the "climate talks.tw" platform is a major online channel for public dialogue on climate issues in Taiwan. It collects public opinions on significant climate policies such as the amendment of the "Greenhouse Gas Reduction and Management Act" and the "Phase II Regulatory Goals." It announces the government's reply in response to the opinions of the public.

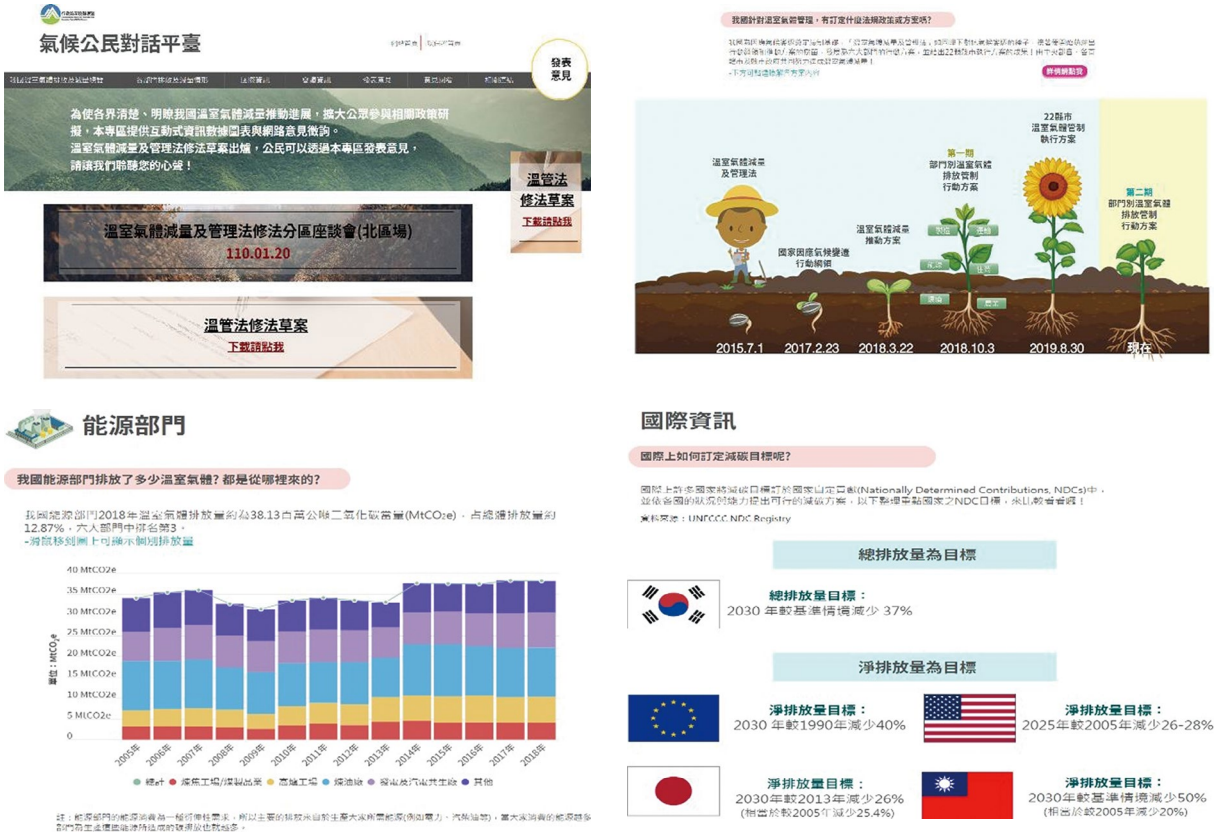

Figure 8.3.1-3: Visualization of policy information in the "climate talks.tw" platform

Source: "Climate talks.tw" platform of the Environmental Protection Administration, Executive Yuan

8.3.2 Promotion of climate empowerment by civil society organizations

Non-governmental organizations (NGOs) in Taiwan are flourishing. In addition to the climate groups focusing on climate change and sustainable development, environmental groups covering a wide range of environmental issues, local community groups focusing on local issues, and foundations established through private investment are all concerned about and engaged in climate change issues. The following is an introduction of the joint response of the government of Taiwan and the civil society organizations to international environmental protection actions, initiatives related to corporate sustainable development promoted by civil society organizations, and activities related to youth climate empowerment promoted by the government as well as the youth groups.

1. Earth Day

Earth Day was first celebrated in 1970 and is an annual event on April 22. Its main purpose is to raise people's awareness of environmental protection. It has been celebrated in 193 countries worldwide and has attracted more than 1 billion people to participate in the event. The theme of 2021 is "Restore Our Earth," calling on people to take practical actions to express their concern for the earth, think about how to reduce the impact on the earth, improve and restore the earth's environment, and jointly prevent disasters caused by damage to the environmental.

Every year on Earth Day, President Tsai Ing-wen meets with representatives of domestic environmental protection groups to learn about their views and suggestions on environmental protection issues. It is hoped that the voice of the people will be included in the decision-making of government agencies, making the administration more comprehensive. President Tsai attended the opening ceremony of the "Sustainability – The solutions for our Earth - Joint Design Action" this year. During the event, she expressed the need to find a climate

governance pathway that is most suitable for Taiwan's sustainable development, transforming the challenge of carbon reduction into new opportunities for industries and employment. In addition, possible pathways to meet the goals of net-zero emissions by 2050 are being actively deployed.

Vice President Lai Ching-te attended the book launch event for Bill Gates's new book, "How to Avoid a Climate Disaster," on the afternoon of Earth Day, saying that Taiwan has no immunity from the issue of climate disaster and should actively face and engage in the issues. As to net-zero emissions, Taiwan must face future issues directly, formulate practical countermeasures, and solve problems pragmatically, finding a new direction for Taiwan's sustainable development.

Figure 8.3.2-1: President and Vice President attend Earth Day activities

Source: Website of the Office of the President, Republic of China (Taiwan)

2. Earth Hour

Earth Hour is an energy-saving initiative launched by the World Wide Fund for Nature (WWF). The event is held annually, encouraging individuals, communities, and businesses to turn off non-essential electric lights, for one hour, from 8:30 to 9:30 p.m. on a specific Saturday at the end of March, so as to raise people's awareness of energy-saving and global warming.

The first Earth Hour event was held in Sydney, Australia, in 2007. Taiwan's NGOs, businesses, and government agencies at all levels have participated in the event since 2010. In 2021, more than 1,178 businesses, government agencies, including the Office of the President, and many well-known buildings, such as Taipei 101 and the Taipower Building, all participated in the event.

According to estimates based on the public information of Taipower, Taiwan has saved nearly 900,000 kWh of electricity since it participated in the event in 2010. In addition, the publicity generated by the collaborative initiatives of the public and private sectors has brought great help to the promotion of Taiwan's climate change policies. This case is also a specific example of the government and the non-governmental organizations working together to respond to international initiatives.

The Office of the President　　Taipei 101

Figure 8.3.2-2: Well-known buildings in Taiwan participate in the "Earth Hour" event

Source: FTV News, "In response to the 'Earth Hour' even, the Office of the President and Taipei 101 turn off lights for one hour," March 28, 2021; Liberty Times, "Earth Hour event starts tonight, estimated to save more than 120,000 kWh of electricity throughout Taiwan," March 27, 2021.

3. Climate parade

The 2020 "Youth Anti Global Warm Parade" was organized by 11 domestic NGOs concerned with the environment and supported by a petition signed by nearly 50 NGOs. The theme of "Climate Reform is Urgent" invited people from all walks of life to join the parade in response to the global campaign of "Fridays for Future," calling on governments to accelerate climate change efforts.

In addition to the parade, NGOs also set up a "Climate Academy" at the venue, referring to the nine stakeholder communities of the United Nations Framework Convention on Climate Change, inviting stakeholders from various fields for a discussion. During the event, they also invited a number of legislators and members of parliament to share their experience in promoting climate change policies, making the parade appropriate for advocacy, public communication, and education. The event was reported by Climate Home News, an important international climate platform.

Figure 8.3.2-3: Youth Anti Global Warm Parade

Source: Taiwan Youth Climate Coalition.

4. RE10x10

RE10x10 was launched by Greenpeace, an international environmental protection organization, in 2020. It aims to promote enterprises in Taiwan to accelerate the use of renewable energy and fulfill their climate and environmental responsibilities. It invites Taiwan's small and medium-sized enterprises to jointly "achieve the goal of using more than 10% of green electricity by 2025" and received initial support from 14 enterprises, including Taiwan Semiconductor Manufacturing Company (TSMC), Taiwan Cement Corporation (TCC), E.SUN Financial Holding Company (E.SUN FHC), etc. In 2021, more than 600 enterprise representatives signed up and participated in the 2nd "RE10x10 Green Power Forum" online.

Figure 8.3.2-4: The 2nd "RE10x10 Green Power Forum"

Source: Website of Greenpeace

5. Taiwan Alliance for Net Zero Emission

To encourage industries of Taiwan to fulfill their corporate social responsibilities, promote the development of global renewable energy, and enable enterprises to achieve global carbon reduction goals, the Taiwan Institute for Sustainable Energy and 27 domestic and foreign companies have established the "Taiwan Alliance for Net Zero Emission." Members of the Alliance cover traditional manufacturing, technology, finance, and service industries, with total revenue accounting for more than 40% of Taiwan's GDP in 2020 and greenhouse gas emissions accounting for nearly 20% of Taiwan's total emissions.

The Alliance's goal is to jointly promote enterprises to achieve 100% net-zero emissions in "office sites" by 2030, and the ultimate goal is to achieve 100% net-zero emissions in "office sites" and "production sites" across Taiwan by 2050. In the future, the "Taiwan Net-Zero Emissions Association" will focus on net-zero emissions-related issues and the promotion of education, build a communication platform for government laws and policies and help achieve a successful net-zero transition in Taiwan.

Figure 8.3.2-5: The inaugural meeting of the Taiwan Alliance for Net Zero Emission

Source: Website of the Taiwan Alliance for Net Zero Emission

6. Youth and National Climate Vision Forum

The Environmental Protection Administration, Executive Yuan held the Youth and National Climate Vision Forum in 2020, inviting civic groups, youth representatives, representatives of related ministries and councils (or committees), and experts and scholars who have been long-term focusing on climate change issues to discuss climate change mitigation and adaptation actions. During the event, the youth and middle-aged representatives discussed the international environmental protection issues based on scientific viewpoints. They proposed specific recommendations for climate policies, including setting long-term reduction targets, establishing an open and transparent multi-dialogue mechanism, strengthening the link between science, technology and climate actions, building climate change capacity for public and private sectors, guiding private sector capital investment and establishing inter-ministerial competent authorities,

Figure 8.3.2-6: Youth and National Climate Vision Forum

Source: Environmental Protection Administration, Executive Yuan, Environmental Protection News

which have fully demonstrated the enthusiasm and innovative ideas of Taiwanese young people, bringing vitality to the government's policy planning.

7. CITI Empowers Taiwan Youth to Tackle Climate Change

Citibank Taiwan joined hands with the Taiwan Youth Climate Coalition (TWYCC) to launch the "CITI Empowers Taiwan Youth to Tackle Climate Change" in 2021, including holding the "Climate Model United Nations" and the first "Youth Climate Diplomacy and Empowerment Forum," connecting Taiwanese youth with international ESG (Environmental, Social and Governance) experts to follow global trends, and launched the "Thousand People Response Plan" on Earth Day, inviting all people to go online and join climate action, hoping to raise people's awareness of climate change and fulfill net-zero carbon emission in daily life.

The Thousand People Response Plan website uses lively and lovely animated videos to illustrate Taiwan's climate change challenges in simple terms. In addition, it also includes an introduction to the background and rules of international climate negotiations in the Climate Model United Nations. Furthermore, the replay of the exciting videos, the dialogue and discussion between star speakers and young generations, and the cross-field sharing of views on climate change during the four recent youth climate diplomacy and empowerment forums: "Climate X Finance X ESG," "Climate X Digital Media," "Climate X Adaptation" and "Climate X United Nations" were gathered. It also connects New York, London, and Taipei for the first time to discuss the latest international trends in ESG and climate change issues. The four youth climate diplomacy and empowerment forums attracted more than 360,000 views, showing that the younger generation in Taiwan is increasingly concerned about climate change.

Figure 8.3.2-7: CITI Empowers Taiwan Youth to Tackle Climate Change

Source: Website of the Taiwan Youth Climate Coalition

8. Climate leader for future

Since 2019, O'right (Hair O'right International Corporation) and the Taiwan Youth Climate Coalition have collaborated to promote the "Climate leader for future" program, recruiting resources and lecturers to help front-line educators implement climate change teaching materials that meet school needs.

The idea of establishing a "climate leader" originated from the concept of assigning a disciplined leader and a health leader in school classes. In this way, climate issues can be brought into schools to increase teachers' and students' awareness of climate change, strengthening the green influence of the whole society. The Taiwan Youth Climate Coalition assists in the training of volunteers and educators to master the basic knowledge of climate change and multimedia teaching resources and collaborates with school teachers at all levels to design climate change-related curricula according to the characteristics of various counties and cities as well as the needs of students. It also sends staff to give lectures in schools.

Figure 8.3.2-8:"Climate leader for future" program promotes climate change education in schools at all levels

Source: Website of the "Climate leader for future" program

References

1. Climate Home News，「As Taiwan models net zero scenarios, campaigners push for 2050 target」，2020 年：https://www.climatechangenews.com/2020/12/14/taiwan-models-net-zero-scenarios-campaigners-push-2050-target/?fbclid=IwAR32z4Jn_XOqNYpFnSVZTBUm8a1dB5puSq2ABcnne2UDrbfCtcqr7mI5KWU.
2. Taiwan Adaptation Platform (TAP) "2019 Report on Capacity Building Results," 2019: https://adapt.epa.gov.tw/TCCIP-1-F/TCCIP-1-F-4.html.
3. "Climate talks.tw" platform of the Environmental Protection Administration, Executive Yuan: https://www.climatetalks.tw/.
4. Environmental Protection Administration, Executive Yuan, Environmental Protection News: https://enews.epa.gov.tw/Page/3B3C62C78849F32F/a93823ce-43d6-41a4-abf1-f7affe27e63e.
5. Website of the Low Carbon Sustainable Information System, Introduction of the Rating System: https://lcss.epa.gov.tw/_x/_lcss/lcssgrade/viewgrade-1.aspx.
6. Website of the "Climate leader for future" program: https://www.facebook.com/%E6%B0%A3%E5%80%99%E8%82%A1%E9%95%B7-Climate-Leader-for-Future-105310074225264.
7. Climate Change Education website, About Us: https://climatechange.tw/Home/Page/6?pageId=5.
8. Climate Change Education website, Innovation Competition: https://climatechange.tw/Creative/Competition?pageId=17.
9. Website of the Climate Change Adaptation Education Teaching Alliance, About the Alliance: http://sdl.ae.ntu.edu.tw/CATA/about.php.
10. Energy Education Resource Center website, Project Introduction: https://learnenergy.tw/index.php?inter=project&id=1.
11. Energy White Paper, White Paper Introduction: https://energywhitepaper.tw/why.html.
12. The Society of Wilderness, "Earth Hour Press Release," 2021: https://www.sow.org.tw/sites/sow/files/huang_ye_bao_hu_xie_hui_xin_wen_gao__gu_ji_guan_deng_wei_na_zhuang_wei_di_qiu_liu_xia_na_dian_lu_.pdf.
13. National Academy for Educational Research, "Issue Integration Instruction Handbook," 2017: https://www.naer.edu.tw/upload/1/16/doc/2027/%E8%AD%B0%E9%A1%8C%E8%9E%8D%E5%85%A5%E8%AA%AA%E6%98%8E%E6%89%8B%E5%86%8A(%E5%AE%9A%E7%A8%BF%E7%89%88).pdf.
14. 2019 Curriculum Information Website of the K-12 Education Administration, Ministry of Education, About the 12-Year Basic Education: https://12basic.edu.tw/12about.php.
15. Ministry of Education Energy Conservation System Integration and Application Talent Cultivation Program, Program Introduction: https://www.energyedu.tw/index.php?inter=about&id=6.
16. Ministry of Education website, Development history of major education policies: http://history.moe.gov.tw/policy.asp?id=24.
17. Website of the Bureau of Energy, Ministry of Economic Affairs, "Energy White Paper (Approved)," 2020: https://energywhitepaper.tw/news01.html.

2021

National Communication of the Republic of China (Taiwan) under the United Nations Framework Convention on Climate Change

行政院環境保護署
Environmental Protection Administration,
Executive Yuan, R.O.C(Taiwan)