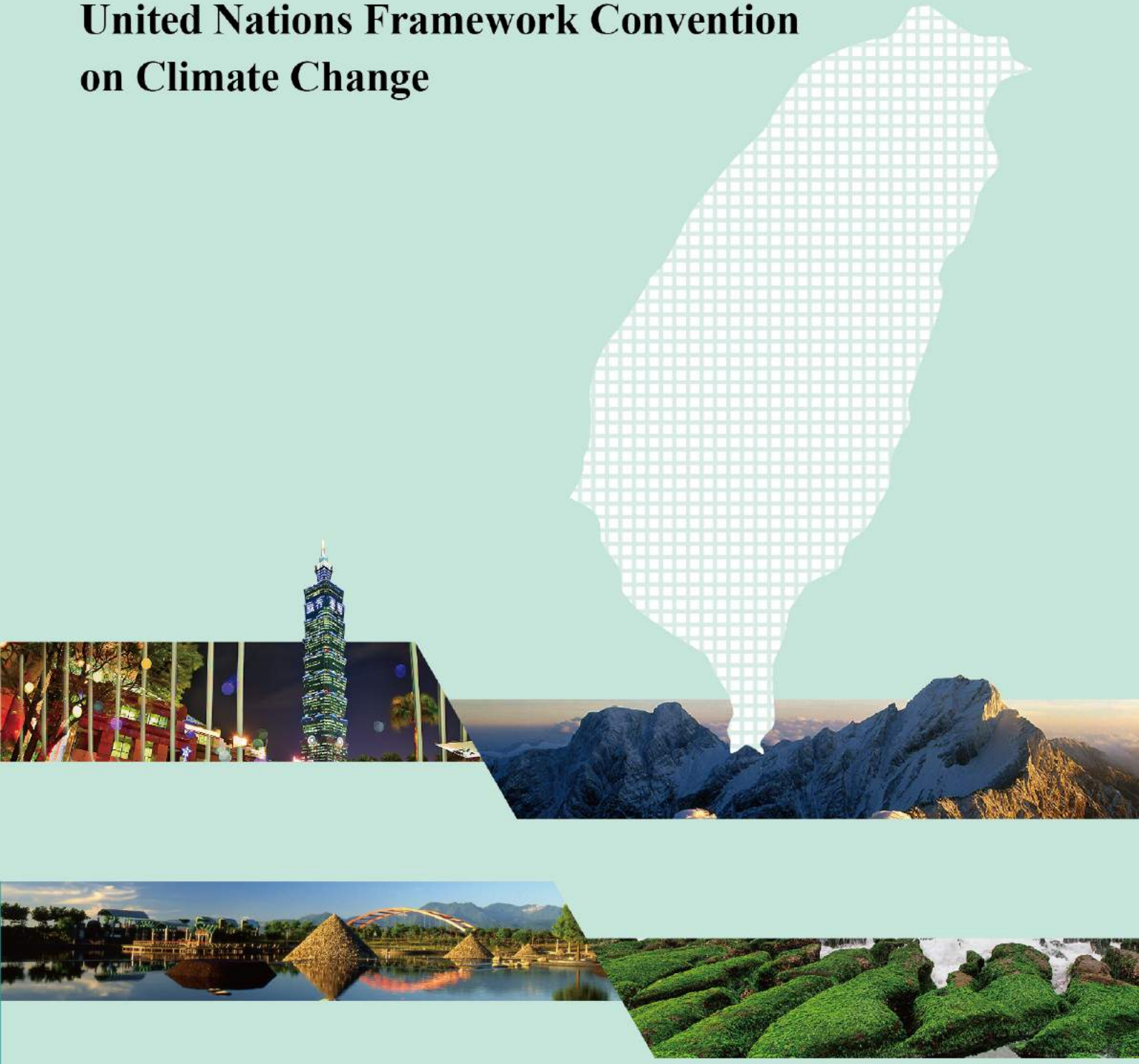
2018

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



Foreword

Chang Tzi-Chin

Minister of Environmental Protection Administration, Executive Yuan

Surrounded by oceans, Taiwan has faced particularly serious impact of climate change. In recent years, the threats of heat waves and heavy rainfall introduced by tropical depression or typhoons have caused major losses to the safety of national's life and property. The Intergovernmental Panel on Climate Change (IPCC) published the "Special Report on Global Warming of 1.5 °C" in October 2018, once again reminding the world that climate change is already scientific facts; meanwhile it is truly and profoundly affecting all places on the earth.

To tackle with the challenge of climate change, Taiwan's strategies and initiatives to promote greenhouse gas reduction and climate change adaptation are abundant and diverse. As of the legal system, the central government has formulated climate policies according to the "Greenhouse Gas Reduction and Management Act" passed by the Legislative Yuan, gradually implementing energy transformation, industrial restructuring, and low-carbon transportation environment building with short, mid and long term reduction targets and management. Local governments also responded to the nation's call and proposed carbon reduction actions which were adapted to local conditions. Energy-saving campaigns have also been launched. Private sectors, academia institution, and civil society organisations are spontaneously participating in the global carbon disclosure program, launching climate initiatives and promoting environmental education, which shows Taiwan's great vitality. In addition, through meteorological observations and early warning of disasters, Taiwan strengthens not only infrastructure but comprehensive management of the river basin, leading to effective reduction of the disaster risk and loss and enhancement of capacity building. Furthermore, the incorporation of climate change to the national education and development of general education curriculum materials all lead to the raising of public awareness, which gradually creates a low-carbon sustainable homeland.

Taiwan has benefited from the development of industrialization in the past, and now should take more responsibilities for saving the planet together with the world. We are eager to share with the international community the efforts and experience in the fields of environmental management system, disaster prevention and early warning system, energy efficiency improvement technology, and scientific innovative application. Global climate change is "a matter of life or death," even if Taiwan encountered the United Nations' negligence, isolation and unfair treatment, Taiwanese people were adversely driven to redouble our efforts. We believe that "Virtue is not left to stand alone," and will continue to uphold the principle of "professionalism, pragmatism and contribution" in addition to striving to participate in international organizations and activities, fulfilling the responsibility of the global citizens. Let Taiwan walk into the world, and let the world see Taiwan.

The publication of the "2018 National Communication of the Republic of China (Taiwan) under the United Nations Framework Convention on Climate Change" brings together Taiwan's efforts in response to climate change, sharing with the world Taiwan's climate actions from the private sectors and civil society. On the eve of the publication, we want to express our thanks to people of all levels of society for their contribution to climate change issues, which strongly supports Taiwan's presence on collaborate with the international community to tackle with climate change.

Table of contents

List of tables

List of figures

Executive Summary

Climate change has been the most serious international environmental issue confronting human survival in the 21st century. In response to the global trend of climate action and regulatory development, Taiwan promulgated its *Greenhouse Gas Reduction and Management Act* (hereinafter "GHG Reduction and Management Act" or "the Act") in 2015. The Act clearly sets out a long-term greenhouse gas reduction target of a 50% reduction of 2005 levels by the year 2050.

Since Taiwan issued the first *National Communication* in 2002 and the second version in 2011, Taiwan's third National Communication has been prepared with the entry into force of the *GHG Reduction and Management Act*. In the spirit of the United Nations Framework Convention on Climate Change (UNFCCC) which requests its parties to regularly publicize their implementation of national climate action, Article 13 of the Act stipulates that the central competent authority shall compile a national GHG report every three years for submission to the Executive Yuan, whose approval will then pave the way for the report's release to the general public. In accordance with the enforcement rules of the Act and the UNFCCC national communication preparation guidelines, the Environmental Protection Administration (EPA) has complied sectoral strategies and outcomes to deal with climate change. Taiwan's third *National Communication* contains nine chapters which cover national profile and basic environmental status, greenhouse gas emission statistics and trends analysis, Taiwan's policies and measures for greenhouse gas reduction, greenhouse gas emission forecast, climate change observation and science study, influence of climate change and adaptation measures, technical R&D, demand and transfer, international cooperation and exchanges, and education, training and public awareness, all of which are summarized as follows:

Chapter 1: National Profile and Basic Environmental Status

Situated at the intersection of East and Southeast Asia, Taiwan borders the Pacific Ocean on the east, the Taiwan Strait on the west, and Bashi Channel on the south, is near the Ryukyu Islands, and spans from 119 to 124 degrees east longitude and from 21 to 26 degrees north latitude. Shaped like a spindle, Taiwan Island is about 394 km long and 144 km wide, has 1,139 kilometers of coastline and a land area of 36,179 square kilometers. Its effective territory includes the main island and affiliated islands--the Penghu archipelago, the Kinmen archipelago, the Matsu archipelago, the Pratas, and the Nansha Islands--covering a total area of 36,179 square kilometers. Taiwan Island has an average temperature of around 24°C . The average maximum temperature is 25 to 29 °C, and the minimum temperature does not exceed 22 °C. The average annual precipitation is about 2,500 mm.

Taiwan's population exceeded 22 million in 1999. By the end of September 2018, the population was 23.58 million. Its average population density is 651 people per square kilometer. After a negative economic growth caused by the financial crisis of 2009, its economic structure led to a surge in 2010 with an economic growth rate of 10.63%. In 2017, the economic growth rate was 2.89%.

Taiwan's energy supply in 2010 was 143.08 million kiloliters of oil equivalent. In 2017, it increased to 146.64 million kiloliters of oil equivalent. For energy supply sources of 2017, self-served energy made up 2.02%, while energy imports made up 97.98% of the total energy supply with oil and coal being the main energy sources. In recent years, Taiwan has actively developed renewables, such as solar, geothermal, wind, biogas, and solar thermal. In energy consumption, the highest consuming sectors were the industrial and transportation sectors.

The transportation industry includes land, sea, and air transportation. Land transportation mainly involves road and railway. As of the end of 2017, the total road length in Taiwan was about 21,713.8 kilometers. Sea transportation covers international and round-the-island service. Air transportation currently involves seven civil air carriers, connecting with 141 cities around the globe with operation of 296 air routes, of which 211 are international passenger routes and 85 are freight routes.

Chapter 2: Greenhouse Gas Emission Statistics and Trend Analysis

Taiwan's greenhouse gas (GHG) emission statistics are derived based on methodology according to the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories and with reference to uncertainty management and IPCC's good practice guidelines. The statistics are estimated by sectoral GHG emission and removal according to actual situations.

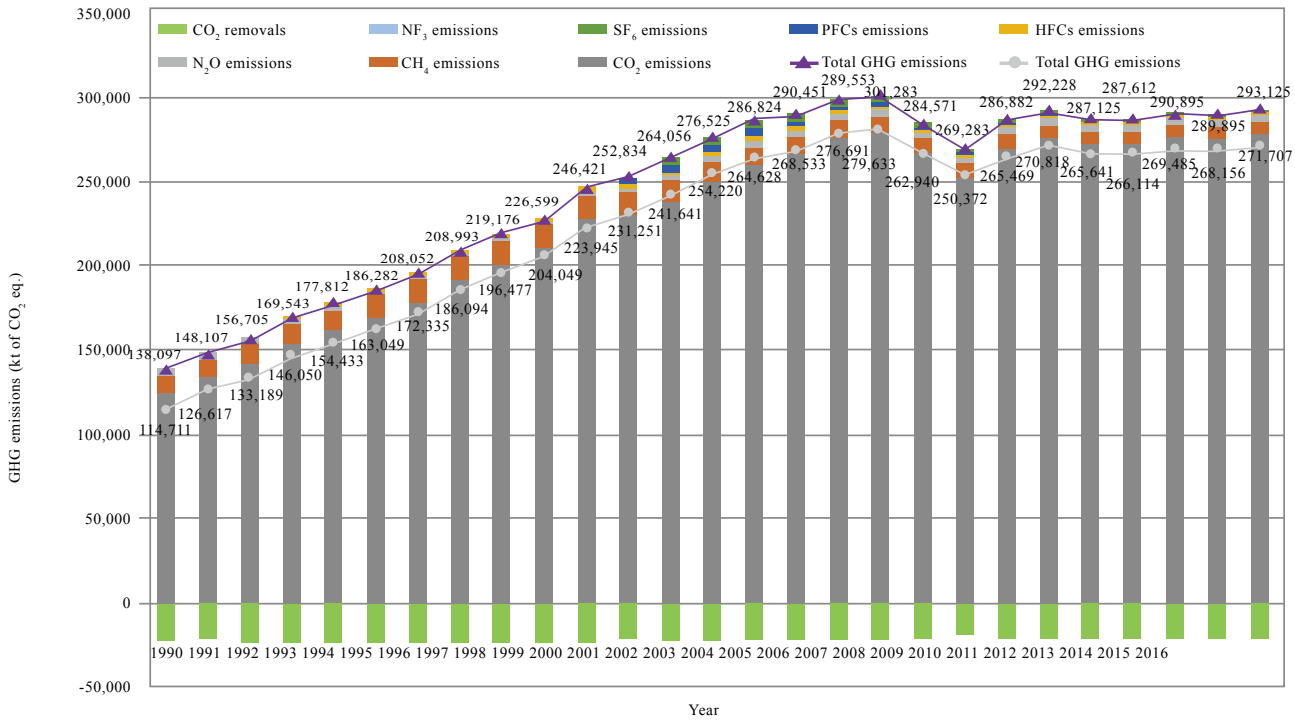


Figure 1 Trends in total GHG emissions and removals in Taiwan from 1990 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

The total GHG emission increased from 138,097 kilotons of carbon dioxide equivalents (excluding carbon dioxide removal) in 1990 to 293,125 kilotons of carbon dioxide equivalents (excluding carbon dioxide removal) in 2016, an increase of 112.26% and an annual growth rate was 2.94%. The data are shown in Figure 1.

By gas type, the largest source of greenhouse gas emission in Taiwan is carbon dioxide, followed by methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), perfluorocarbon (PFCs), hydrofluorocarbon (HFCs), and nitrogen trifluoride (NF_3). Between 1990 and 2016, trends in GHG emissions by sector are shown in Figure 2.

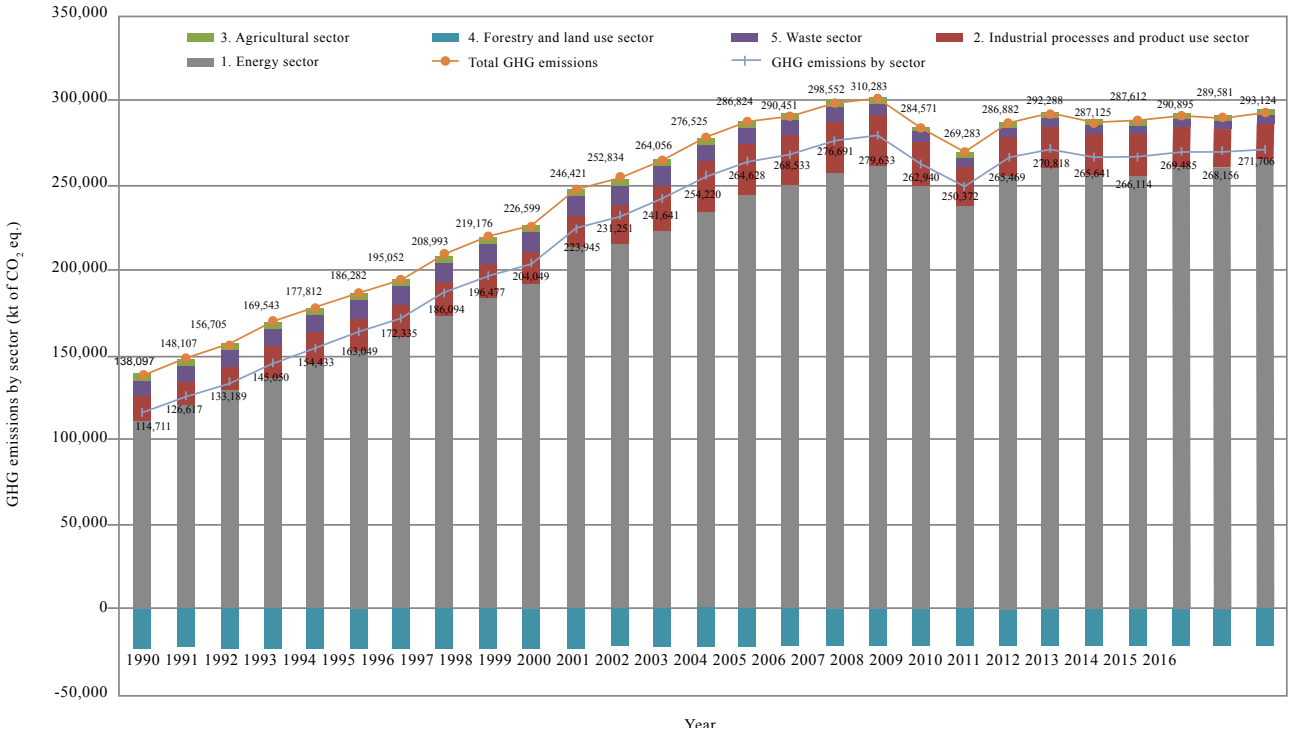


Figure 2 Trends in GHG emissions by sector in Taiwan from 1990 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Chapter 3: Taiwan's Greenhouse Gas Reduction Policies and Measures

In response to climate change and calls for GHG reduction, which can be local, regional and international issues, Taiwan regards combating climate change as part of international cooperation and a collective responsibility and has made every effort to incorporate the spirit of the UNFCCC into its domestic law.

On legislation with respect to greenhouse gas reduction, Taiwan has the *Greenhouse Gas Reduction and Management Act*, the *Renewable Energy Development Act*, and the recently amended *Energy Management Act* and the *Electricity Act*. The *GHG Reduction and Management Act* is the legal foundation for the country to address climate change, obligating the central and local authorities to work on climate change mitigation and adaptation from their respective levels.

In accordance with the *GHG Reduction and Management Act*, the *National Climate Change Action Guideline* was approved by the Executive Yuan in 2017, which proclaims Taiwan's policy orientation in response to climate change upholds the balancing of mitigation and adaptation, setting out 10 basic principles for the nation's climate action. Meanwhile, the *GHG Reduction Action* Plan approved by the Executive Yuan in 2018 covers periodic regulatory goals, six sectoral reduction strategies for energy, manufacturing, transportation, residential and commercial, agriculture and environment, and eight inter-ministerial supporting policies. The criteria and indicators are set out for evaluation, which aim to integrate the performance from ministries to collaboration on GHG reduction.

The promotion strategies for the energy sector include: building a supply system of low-carbon energy; promoting energy transition, by 2025 expanding the use of renewable energy to 20%, natural gas to 50%, and gradually reducing coal-fired power generation below 30%; reducing power emission factors per degree from 0.529 kg CO_2 in 2016 to 0.492 kg CO_2 in 2020.

The promotion strategies for the manufacturing sector include: upgrading industry guidance on GHG reduction; launching industry transformation; and carrying out sustainable process of production. By 2020, the sector expects to lower 43% carbon intensity compared with 2005; and will boost an estimated NT$25 billion investment.

The promotion strategies for the transportation sector include: gradually increasing the traffic volume of public transportation to 7% growth in 2020 compared with 2015; switching the use of private vehicles to public transit systems; driving 100% electrification of public-owned vehicles and urban buses by 2030, electrification of newly sold motorcycles by 2035, and electrification of newly sold cars by 2040.

The promotion strategies for the residential and commercial sector include: improving the energy-saving design benchmark value of building exteriors; strengthening management of GHG reduction for existing buildings; planning and building mitigation ability of the competent authorities of the commercial sector.

The promotion strategies for the agriculture sector include: purchasing and recycling fishing ships and vessels; rewarding fishing season off; promoting organic and eco-friendly cultivation; implementing dual

system of green environmental payment and guaranteed purchase; promoting reuse of animal farm biogas for electricity generation; maintaining and securing the self-sufficiency rate of livestock and poultry products; reforestation; enhancing forest management.

The promotion strategies for the environment sector include: considering resilience building and mitigation plans during policy making and environmental assessment on development projects; realizing circular use of energy and resources to explore an open and shared economy society; improving reuse of regional energy and resources; reducing GHG emission from the process of waste and sewage treatment.

Chapter 4: Greenhouse Gas Emission Forecast

Taiwan has set long-term targets for GHG reduction, and regulatory goals in stages on a five-year basis in accordance with the *Greenhouse Gas Reduction and Management Act*. This chapter introduces the forecasts of GHG emissions of various sectors from 2017 to 2030 through hypothetical scenarios and model tools based on the allocation of reduction targets among sectors and national reduction path planning.

To present the outcome of sectoral forecast on the same scenario and background, the common design conditions include overall economic growth forecasts, population and household growth projections, and power demand forecasts. It is estimated that Taiwan's net GHG emissions in 2020 will decrease by 2.09% compared with the base year of 2005, 1.01% compared with the year 2015. By sector, in 2020 energy and transportation sectoral emission will increase compared with the year 2015. The net GHG emissions in 2025 will decrease by approximately 9.88% compared with the base year of 2005; in 2030 it will decrease by approximately 10.06% compared with the base year of 2005. Taking into account of the uncertainty and that Taiwan's pathway of reducing carbon emissions slowed down before accelerated, the nation's total net GHG emissions will fall to 260.717 million Mt CO_2e by 2020, and 10% down by 2025 compared with the base year, and 20% down by 2030 compared with the base year as part of future efforts.

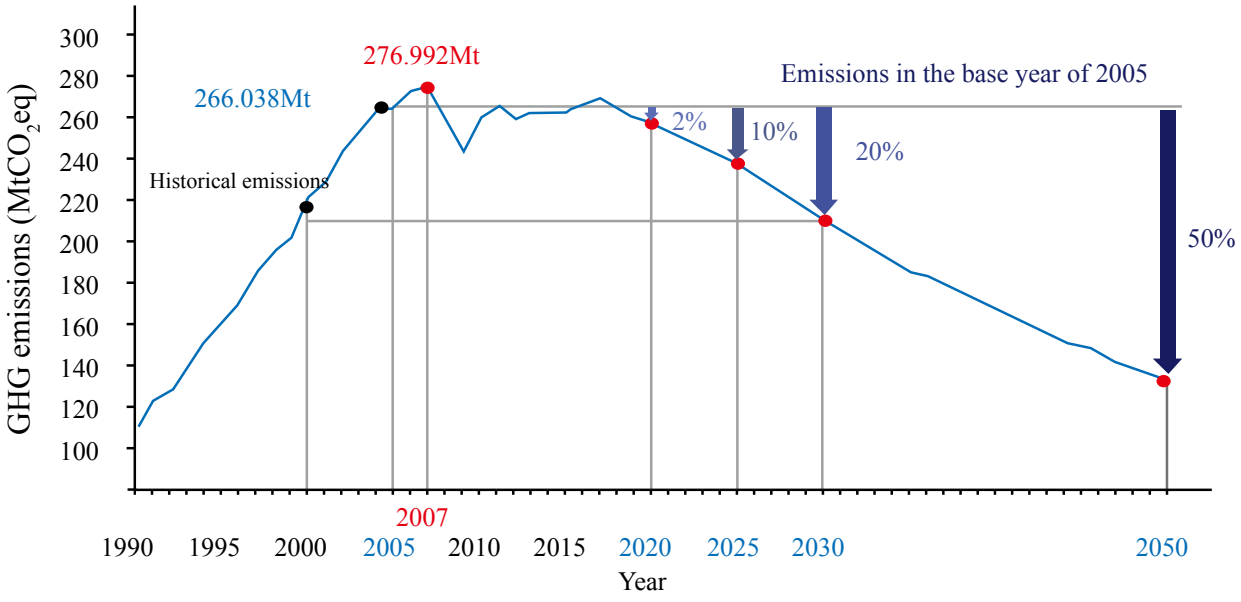


Figure 3 GHG reduction path in Taiwan

Source: Executive Yuan Environmental Protection Administration

Chapter 5: Climate Change Observation and Science Study

Taiwan's weather observation mainly covers ground and high altitude weather observation, radar weather observation, sea state observation, and hydrologic observation. They include various meteorological elements and atmospheric data, such as wind direction, wind speed, rainfall, barometric pressure, temperature, hydrology, sea state, ultraviolet ray, air quality and atmospheric composition, in addition to meteorological satellite observation. Besides satellite information from the United States and Japan, the FORMOSAT-3/COSMIC satellites developed by the National Space Organization of the National Applied Research Laboratories observe global atmospheric conditions and provide Taiwan and meteorological institutions worldwide with pertinent data.

To improve its capabilities in meteorological observation, forecasting and climate change research, Taiwan launched the Disastrous Weather Monitoring and Forecasting Operations Construction Program (2010-2015) and the Climate Change Application Service Capacity Development Program (2014-2017). Its research focused on climate model development and application, climate change analysis, and climate application promotion. Based on climate science data accumulated over the past, the government formulates response, adaptation measures and decision-making on climate change, while developing scientific research on climate change and performing specific impact assessment.

Given Taiwan's geographical condition of being surrounded by the ocean, sea state observation is a focus of climate change research and response. Future work of climate forecasting will aim at establishing a joint ocean-atmosphere forecasting system, which combines ocean circulation models with atmospheric ones, while predicting the state of the ocean and atmosphere, so that the two-way interaction between the ocean and atmosphere can be simulated more accurately. Future work of climate system observation will include promoting refined and customized service of meteorological data and smart application; improving facility and forecasting skills of sea state observation to enhance environmental service on sea area disaster prevention; developing the ability to warn against natural disasters, such as earthquakes and tsunamis.

Chapter 6: Climate Change Impact and Adaptation Measures

In the past four decades (from 1980 to 2017), temperature rise in Taiwan accelerated significantly at an increasing rate of about 0.30 to 0.50°C every 10 years. From 1900 to 2017, the average temperature of the whole year and the summer half of the year (May-October) increased by about 1.3°C, while the winter half of the year by 1.2°C. In the last century, precipitation varied between the south and the north; and due to the increasing fluctuation in precipitation in a year between the rainy season and non-rainy season, the difference between dry season and wet season has become more and more pronounced. Although total precipitation has not changed much, the chance of heavy rainfall has increased. From 1970 to 2010, the typhoons that struck Taiwan show a trend of decelerating in speed but longer periods of influence. Meanwhile, precipitation of heavy rainfall (the level of 95 percentile) has increased.

In 2010, Taiwan has set up a task force to "plan and promote climate change adaptation policy guidelines and action programs," jointly develop the

Adaptation Strategy to Climate Change in Taiwan and construct a framework for promoting adaptation in Taiwan. Referring to the future situation and research results of climate change in Taiwan discussed in the *2011 Taiwan Climate Change Science Report*, as well as to the adaptation actions taken by various countries and the particularity and historical experience of Taiwan's environment, the *Adaptation Strategy to Climate Change in Taiwan* which was approved by the Executive Yuan in 2012 divided national adaptation into eight areas that are most seriously affected: disasters, infrastructure, water resources, land use, coastal zones, energy supply and industry, agricultural production and biodiversity, and health. To put the adaptation strategy into action, eight working groups are set up under the Organization of the National Adaptation Policy Framework to assist in planning and promoting adaptation-related work, which have been compiled with the *National Climate Change Adaptation Action Plan* (2013-2017) by the National Development Council (NDC).

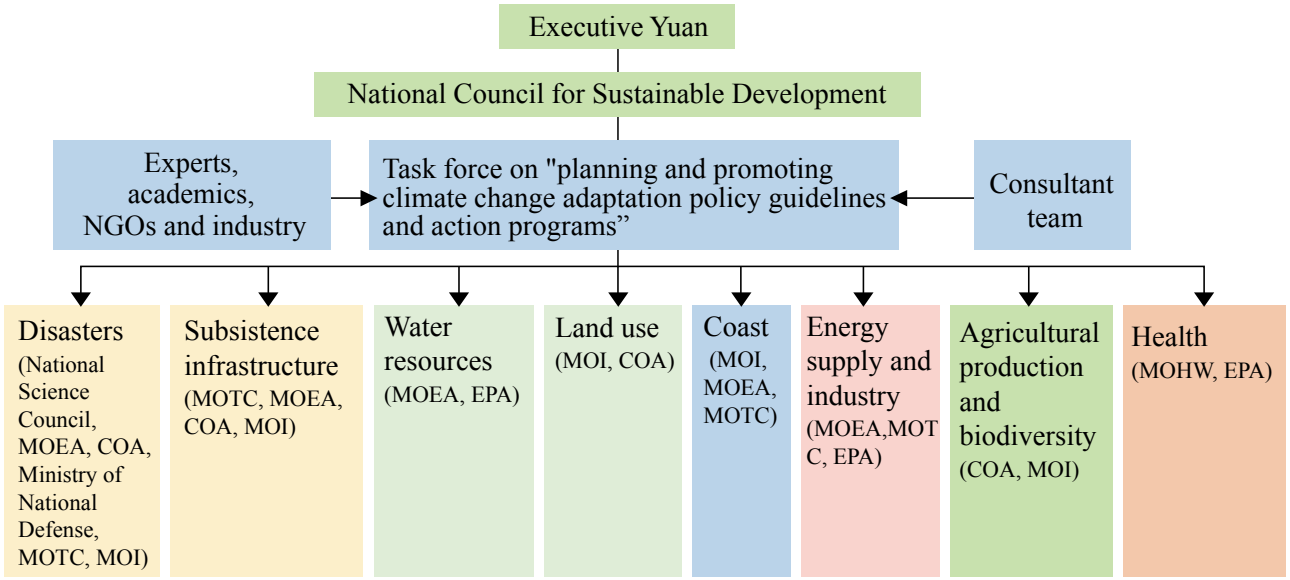


Figure 4 Taiwan's national climate change adaptation policy guideline and division of work in eight areas among the ministries

Source: NDC, National Climate Change Adaptation Policy Guidelines, 2012.

Chapter 7: Technical R&D, Demand and Transfer

To develop available technology and techniques to respond to climate change, the international community has incentivized technology R&D, innovation and cooperation. Collaborated with global market mechanism and climate financing, countries stocktake and list the technology and techniques items that they need, planning and promoting domestic action plans to import or export relevant technology for technology transfer and diffusion. Taiwan also invests in the R&D of climate technology, climate service, and relevant industries, which can be divided into two categories of the "mitigation and energy technology" and "climate service and adaptation technology." Cases of technology demand and technology transfer will be introduced.

As for the development of climate technology, climate service, and relevant industries, Taiwan promotes "mitigation and energy technology" with the R&D program of National Energy Program Phase I (NEP I) in 2007 and Phase II (NEP II) in 2014, studying the basis of energy technology, emphasizing the implementation of energy industry, focusing on verification of technology industrialized potential, and applying the results to implementation. The NEP programs have made significant progress in the focus of energy conservation, alternative energy, smart grid, offshore wind power and marine energy, geothermal and gas hydrate, carbon reduction and clean coal, which play important roles in the area of energy technology. Faced with the influence and impacts of climate change, Taiwan is developing climate service and adaptation technology, providing climate forecasting information based on science and climate service for the public to be aware of climate risk and the and government to manage it. Information on climate change analysis and projections is provided as reference for government authorities when planning climate change adaptation strategies.

Taiwan's climate change technology roadmap involves technology R&D, diffusion and transfer as tools to identify the natural conditions and technology demand of Taiwan's marine energy; and importing applicable offshore wind power technology. In the spirit of the UNFCCC and Paris Agreement, Taiwan is promoting and endeavoring to participate in global climate cooperation with competent authorities and relevant ministries of international aid. To implement mitigation and adaptation technology during international climate actions, Taiwan makes solid contribution via technology transfer to its friendly or ally nations, such as the Solomon Islands, Nicaragua, Honduras, Saint Christopher and Nevis, and Myanmar.

Chapter 8: International Cooperation and Exchange

Taiwan is building multilateral and bilateral cooperation on climate change response with various countries through multiple approaches at all levels, ranging from central and local governments, to industry, academia, and NGOs. In collaboration with global and regional networks, Taiwan shares with members of the international community its experience in the fight against climate change in a joint effort to address its impacts and challenges. Taiwan's international cooperation and exchange in climate change has three aspects:

In the area of collaboration with other countries and government organizations, in light of the possible range of operation both financially and technologically, Taiwan assesses the cooperation

needs of partner countries, distributing resources with project-orientation and SOP. Starting with objective setting, a cooperation project stipulates basic working criteria and implementation terms according to the selection, assessment, negotiation, implementation and evaluation of the project. The implementation quality and benefits are highly valued. Cooperation projects may include any of four categories: lending and investment, technical cooperation, humanitarian assistance, and international education and training.

In terms of collaboration with local governments and municipal authorities, ten cities in Taiwan are members of the International Council for Local Environmental Initiatives (ICLEI-Local Governments for Sustainability) in 2018. Through participating in ICLEI's selection activities of low-carbon demonstration cities, Taiwan's cities incorporate the idea of "low-carbon city" to its governance with comprehension and mind-set of being low-carbon. In 2011, the Kaohsiung City Government acquired the honor to establish ICLEI Kaohsiung Capacity Center (ICLEI KCC), and in September 2012 launched its services. Three Taiwan cities have become members of CityNet and are involved in its sustainable cities campaign promoted in the Asia-Pacific region.

In the area of collaboration with non-governmental organizations (NGOs), Taiwan has devoted itself to the activities of the nine constituencies under UNFCCC NGO observers and international exchange. In the Business and industry NGOs (BINGO), airline and shipping enterprises voluntarily joined international cooperation project to collect atmosphere and sea area observation data through installed devices on aircraft and vessels for shared use of the World Meteorological Organization (WMO) and pacific region. The steel industry, semiconductor industry, and electronics industry join international industry associations for GHG emission reduction campaign and actions. As for research and independent NGOs (RINGOs), Taiwan focuses on issues of low-carbon technology and climate change governance, observing and tracking the negotiation development and progress of the UNFCCC. The most active constituency in Taiwan is the Environmental NGOs (ENGOs), which cover activities of environmental protection, public participation and climate education. Taiwan also has long-term contribution and participation in the Women and Gender CC and Youth NGOs (YOUNGO), showing the diversity and autonomy of Taiwan's civil society.

Chapter 9: Education, Training and Public Awareness

The regulatory basis of climate change education, training and public awareness include the *Environmental Education Act* and the *GHG Reduction and Management Act*. For climate adaptation education, the Adaptation Strategy to Climate Change in Taiwan is referred. For energy education, the action plans of the National Energy Conference are depended on. The solid activities of education, training and public awareness can be introduced by school education, job training, public awareness and civil society autonomy promotion.

In school education, Taiwan nurtures climate change adaptation talents through the dual strategy of training both laymen and specialists. The laymen cultivation strategy involves developing teaching materials for elementary, junior high, senior high schools and universities, incorporating climate change as a critical issue in the *Directions Governing the 12-Year Basic Education Curricula*. The specialist cultivation strategy, on the other hand,

has incorporated the concept of climate change in the form of professional courses, coupled with the network for teachers and the mode of industry-university cooperation. The energy education strategy has designed teaching materials for elementary schools and high schools, built education centers and benchmarked model campuses. Further cultivation programs for energy technology talents are launched with information websites and six centers of energy and technology education network. In teachers training, the Teaching Alliance on Climate Change Adaptation Education and Center for Teacher Training on Energy and Technology Education have been established. In cultivation of academic specialists, professional energy technology talents with a master's or doctoral degrees are trained through conducting academic study and publication under National Energy Program Phase II (NEP II).

In job training, the Energy Management Institute holds training for energy managers. The qualified and certified ones can assist approximately 4700 big energy consumers to effectively manage energy use. The Ministry of Economic Affairs (MOEA) holds training of specialists in GHG reduction and management in the energy industry, who have been supporting and guiding the industry to take greenhouse gas inventory, verification, and registration since 2005. The MOEA also started talents training on energy saving and carbon emission reduction specially for the manufacturing industry.

In public awareness, since 2010 the Environmental Protection Administration (EPA) started to promote the low-carbon and sustainable homeland movement. Integrating the energy and resources of central and local governments and the private sector, the movement began from demonstration of participating units at the community level, such as townships and villages, and gradually expanded to the municipal level. While community colleges promote Community Based Adaptation (CBA), localized CBA learning centers are built, and communities develop various objectives to fit local culture. Climate change adaptation has also been promoted online and a platform was launched as a place for information sharing, environmental education, and public dialogue.

▲Yushan National Park

Chapter 1
National Profile and Basic Environmental Status

Chapter 1
National Profile and Basic Environmental Status

The natural environment, social structure, economy and the type of development of a country profoundly affect the country's greenhouse gas (GHG) emissions levels, as well as the impact on climate change. This chapter will present Taiwan's national profile and environmental status from the perspectives of governmental organization and legislation, population, economy, geographic location and land use situation, climate, energy, transportation, industry, wastes, buildings and urban structure, and agriculture, forestry, fishing and husbandry.

1.1 Government Organization and Legislation

1. Central Grovernment

The Republic of China (Taiwan) government is operating in accordance with the Constitution, the Constitutional Amendments and the relevant laws and regulations. The President, the Executive Yuan, the Legislative Yuan, the Judicial Yuan, the Examination Yuan and Control Yuan jointly exercise the power of governance. According to the Constitution, the President, who is the head of state, is directly elected by the people, serves a four-year term and can be re-elected once.

The Executive Yuan, headed by the Prime Minister, is the executive branch of the ROC government. The President directly appoints the Prime Minister. Upon the recommendation of the Prime Minister, the President appoints the other members of the Executive Yuan Council or Cabinet—comprising the vice premier, ministers, chairpersons of commissions, and ministers without portfolio. The current Executive Yuan's organization includes 14 ministries, 8 commissions, 3 independent authorities, the Central Bank, the National Palace Museum and 2 directorate-generals (29 authorities in total). The structure of the Executive Yuan is shown in Figure 1.1.1.

The Legislative Yuan is the parliament of the ROC government. The parliament is constituted by the Legislative Yuan members who represent the people to exercise legislative power. The Judicial Yuan is the judicial branch of the ROC government, which adjudicates civil, criminal and administrative cases in addition to cases concerning disciplinary measures with respect to public functionaries. The Examination Yuan operates the power of examination of the ROC government. The Control Yuan is the highest control authority of the nation that exercises the powers of impeachment, corrective measures and censure.

In May 2018, the Cabinet passed few draft amendments as organizational acts for the Ministry of the Interior (MOI) and 42 other government agencies to reassign and consolidate government responsibilities and tasks according to nature and function, which will ensure the work is undertaken effectively and efficiently. To align with Executive Yuan's adjusted structure, the MOI Act draft reforms the MOI and reorganizes other ministries into new units, including a Ministry of Environment and Natural Resources, a Ministry of Economic and Energy Affairs, a Ministry of Transportation and Construction, and a Ministry of Agriculture. The amendments have been resubmitted to the Legislature for deliberation.

Figure 1.1.1 Taiwan national GHG inventory preparatory procedure

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

2. Local Government

The Local Government Act has adopted several amendments, which subdivided local governments into the provincial government and special municipalities. The 6 special municipalities include Taipei City, New Taipei City, Taoyuan City, Taichung City, Tainan City, and Kaohsiung City. The provinces of Taiwan include the 11 counties of Yilan County, Hsinchu County, Miaoli County, Changhua County, Nantou County, Yunlin County, Chiayi County, Pingtung County, Hualien County, Taitung County, and Penghu County; and 3 cities, which are Keelung City, Hsinchu City and Chiayi City. Together with Kinmen County and Lienchiang County of the Fujian province, the act governs 13 counties and 3 cities. Townships, county-administered cities and districts sum up 146 townships, 38 towns, 14 county-administered cities and 170 districts.

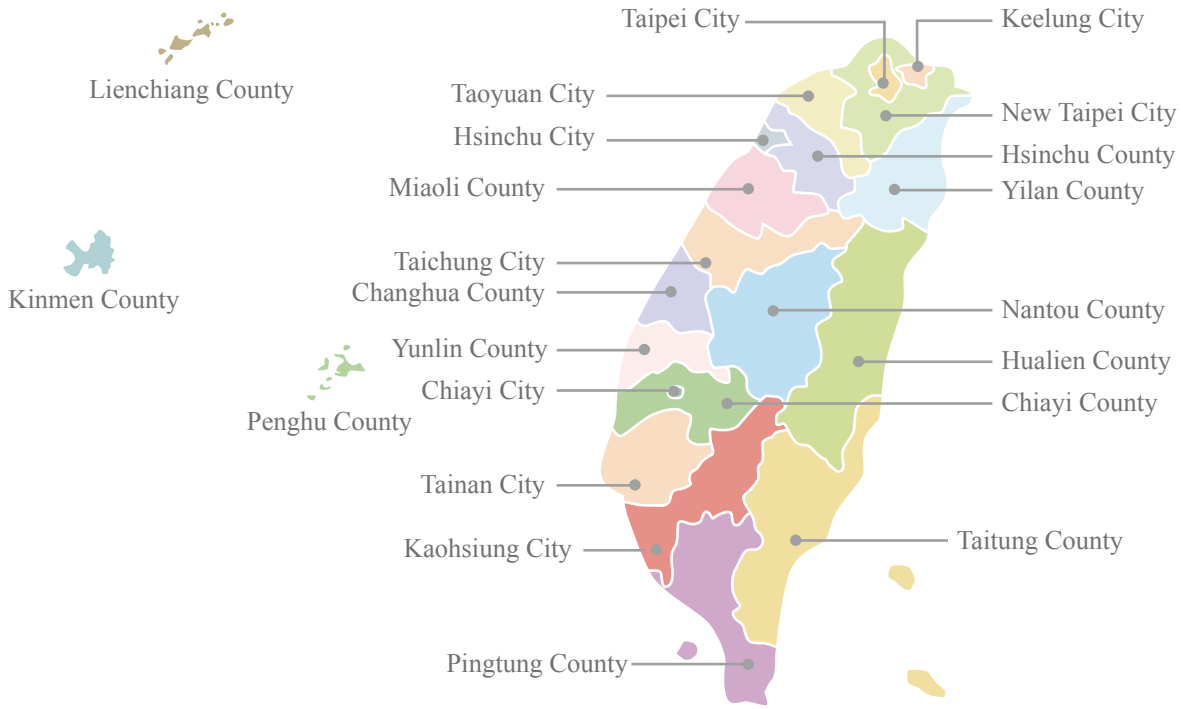


Figure 1.1.2 Structure of the existing Taiwan local governments

Source: Officicial website of Monistry of Interior, Republic of China (Taiwan)

1.2 Population

Taiwan's total population is approximately 23.58 million people. As of the end of September 2018, the majority of the population lived in the special municipalities, accounting for 69.26% of the nation's total population. Taiwan's average population density is 651 people per square kilometer, ranking in the top 2 among countries with over 10 million people in population. The capital, Taipei City, has an average population density of 9,872 people per square kilometer, being the city with the highest population density in Taiwan.

In September 2018, young population (0-14 years), which has been declining year by year, accounted for 12.98%; working-age population (15 to 64 years) accounted for 72.68%; and elderly population (aged 65 and above) accounted for 14.35%, increasing year by year. The average age is 41.35 years old. There is a significant trend shifting towards an ageing society.

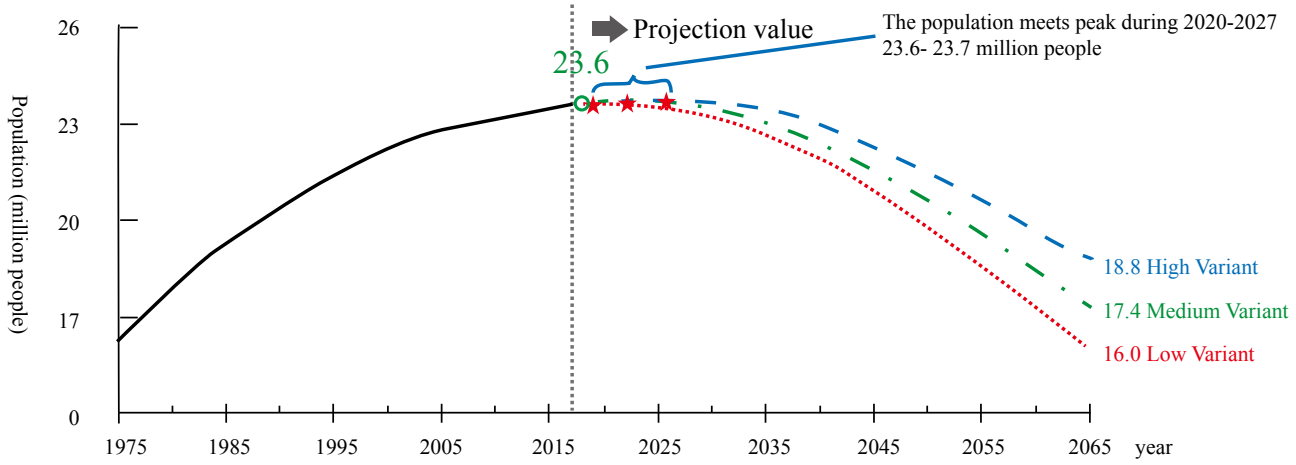


Figure 1.2.1 Trend of Taiwan's overall population

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

1.3 Economy

In 2017, Taiwan's economy grew by 2.89%, with a stable cost of living. The employment situation has improved due to the gradual recovery of the economy. Additionally, the government's encouragement for supportive employment actions has led to a declined unemployment rate of 3.76 %, reaching the lowest point since 2001. The evolution of economic development is shown in Table 1.3.1. Taiwan's economic structure allowed a substantial improvement in the economy in 2010, with economic growth of 10.63% after the negative values observed in the economy during the 2009 financial crisis. Taiwan's gross domestic product (GDP) in 2017 was USD 574,940 million. The same year, the GDP per capita reached USD 24,408. In 2018, the government continued policies of structural reform and investment enhancement to boost domestic demand while maintaining a stable foreign demand. The economic growth projection for the year is around 2.66%.

Table 1.3.1 Trend of Taiwan's economy development by year

Year	Economic Growth Rate (%)	Gross Domestic Product (GDP) (million USD)	Per Capita GDP	
			(NTD)	(USD)
2009	-1.57	392,065	561,636	16,988
2010	10.63	446,105	610,140	19,278
2011	3.80	485,653	617,078	20,939
2012	2.06	495,845	631,142	21,308
2013	2.20	511,614	652,429	21,916
2014	4.02	530,519	688,434	22,668
2015	0.81	525,562	714,774	22,400
2016	1.51	531,281	730,411	22,592
2017	3.08	574,940	742,976	24,408

Source: Directorate General of Budget, Accounting and Statistics (DGBAS) of Executive Yuan, National Statistics Website of ROC (Taiwan)

1.4 Geographic Location and Land Use Situation

The effective territory of the Republic of China (Taiwan) covers a total surface of 36,179.067 square kilometers. It includes the main island and the affiliated islands, which are the Penghu archipelago, the Kinmen archipelago, the Matsu archipelago, the Pratas and the Nansha Islands.

Located at the edge of the Pacific Ocean and the southeast of Asian continental shelf, Taiwan borders the Pacific Ocean on the east, the Taiwan Strait, across which there is the Fujian Province of Mainland China, on the west; the Bashi Channel on the south and the Ryukyu islands on the northeast. Shaped like a spindle, Taiwan Island is 394 km long and 144 km wide, with a total coastline of 1,139 kilometers. It spans from 21 to 26 degrees North latitude, with the Tropic of Cancer crossing Shueishang Township, Chiayi County at 23.5 degrees North latitude.

With land descending from east to west, Taiwan Island is mainly in mountainous terrain, with hills, basins, tablelands and plains. Mountains make up about two-thirds of the main island. From east to west, there are the Coastal Mountain Range, the Central Mountain Range, the Snow Mountain Range, the Yushan Mountain Range and the Alishan Mountain Range. Among them, the Central Mountain Range has the steepest terrain, forming the backbone of the island and also dividing the rivers flowing to the east and the west. West side of the Alishan Mountain Range is sloping with basins and plains. From north to south, there are Taipei Basins, Taoyuan, Hsinchu and Miaoli tablelands, Taichung Basins, Chianan Plains, and Pingtung Plains.

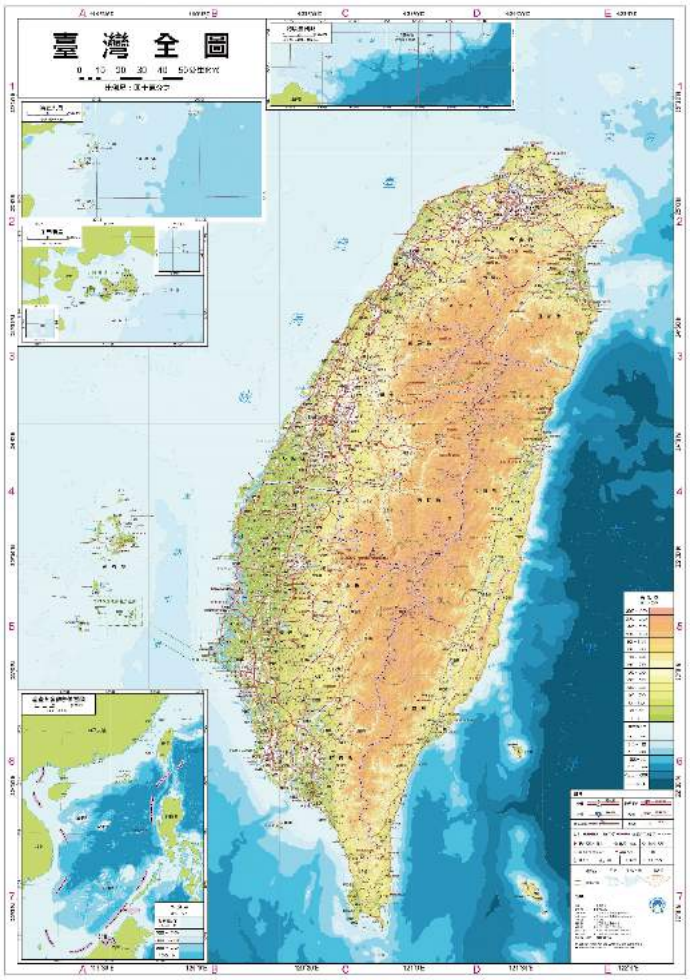


Figure 1.4.1 Taiwan Island Map

Source: Executive Yuan ROC (Taiwan) Website

Land resources can be divided into plain areas, hillsides and mountainous forest lands. The plain area provides croplands for agriculture production. The rest is used as urban, industrial and commercial buildings, industrial districts, public transportation or hydraulic engineering. With continuous economic development, population and industries have agglomerated around urban areas, accelerating urbanization trends. As Acts such as "The Hualien-Taitung Area Development Act" and "Offshore Islands Development Act" have been promoted to balance regional and township development for the Hualien-Taitung Area and Offshore Islands; through improving regional industrial dynamics and encouraging local employment.

The Executive Yuan approved "Strategic Plan for National Spatial Development" in 2010 with visions set at the development of the national land which will turn Taiwan into a country of "safe natural ecology," 'prime living and health," 'a knowledge-based economy and international logistics,", and is "energy saving, carbon reducing, and water conserving."

Promulgated in 2016, the "Spatial Planning Act" divided the work into 'National spatial plan' and 'Municipality or county (city) spatial plans'. This

Act specifically establishes guidelines to meet the demands of homeland conservation and management. According to the nature of land resources, the National spatial plan demarcated four functional zones, including environmental conservation zones, marine resource zones, agricultural development zones and urban-rural development zones.

1.5 Climate

Situated at the East Asia coastal area and Monsoon Asia, Taiwan is visited by the northeast monsoon in winter accompanied by continental cold, and by the southwest monsoon in summer with arrivals of tropical depressions. The Tropic of Cancer crosses the middle of Taiwan Island. Its climate is subtropical and tropical oceanic. In the recent decade, the long-term trend of Taiwan's average temperature had a linear increase and interdecadal variation. Taiwan has an average temperature of approximately 24°C. The average maximum temperature is around 25 to 29°C, and the minimum temperature does not exceed 19 to 22°C. Temperatures remain above 20°C after March for nine months and can reach up to 40°C during the highest temperatures in summer by synergism of urban heat island effect. Variation patterns of average temperature anomaly in Taiwan from 1910 to 2010 are shown as Figure 1.5.1.

The meteorological system of East Asian, characterized by monsoon circulation, fronts and typhoons, influences the precipitations of the island. Taiwan experiences different types of showers, including spring rain, plum rain, typhoon rain, southwesterly flow rain and northeast monsoon rain. Due to the terrain composition and the monsoon patterns, rainfall in different regions and seasons varies significantly. In general, the mountains receive more rainfall than the plains by up to 4,000 mm; the eastern region experiences more rainfall than the western, and the windward areas have more precipitation than the leeward areas. As typhoons bring abundant rain, disasters usually accompany. Due to various paths of typhoons and the effect of the Central Terrain, precipitation varies from region to region.

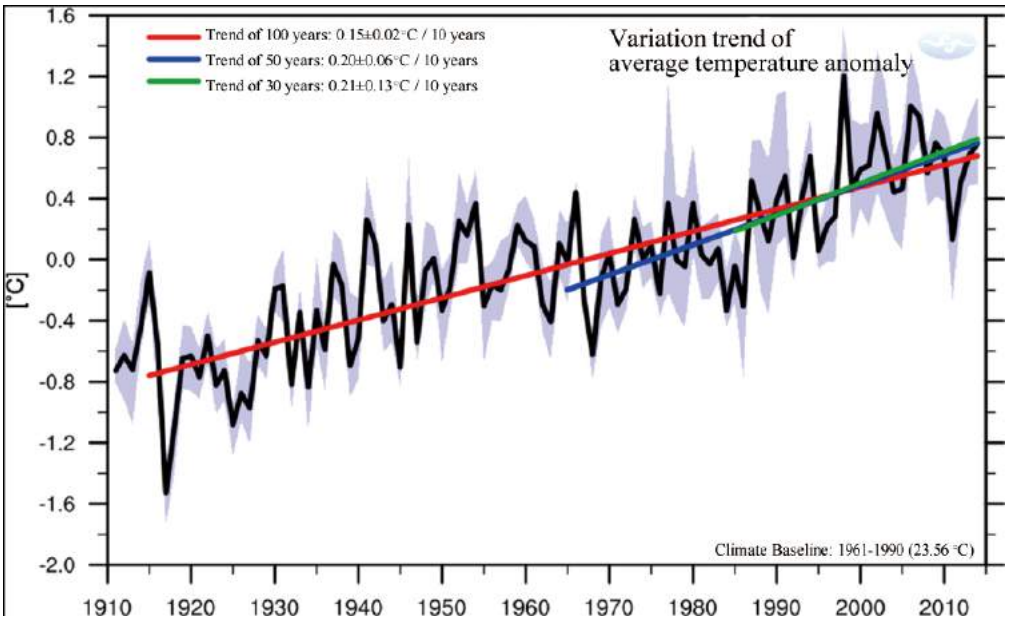


Figure 1.5.1 Variation trend of average temperature anomaly in Taiwan during 1910 to 2010

Source: MOTC Central Weather Bureau Website

1.6 Energy

Taiwan lacks energy resources and relies heavily on imported energy. Taiwan's dependency on energy imports is extremely high, while the electricity system is isolated and hardly redundant. Under international fluctuation of energy supply prices, the pressure of global GHG emissions and the increasing domestic demand for energy, Taiwan faces much more serious challenges on energy development compared with other countries. The current energy situation is presented as follows:

1. Energy Supply

In the past two decades, Taiwan's energy supply has experienced rapid growth. While in 2010 energy imports accounted for 143.08 million kiloliters of oil equivalent, imports have reached 146.64 million kiloliters of oil equivalent in 2017. Table 1.6.1 illustrates Taiwan's energy supply structure by year. With regards to the composition of energy supply sources in 2017, self-served energy made up 2.02% while energy imports accounted for 97.98% of total energy supply, which emphasized Taiwan's reliance on imported energy. By analyzing energy sectors, coal represented 30.17%, oil 48.45%, natural gas 15.15%, biomass and wastes 1.15%, water generation 0.36%, nuclear 4.43%, solar, geothermal, wind and biogas 0.22%, and solar thermal 0.08%. The energy mix by sectors is also shown in Table 1.6.1. While the proportion of renewable energy has annually increased, the proportion of nuclear power has declined since 2015.

Taiwan's power generation capacity has gradually increased by year, up to 270.28 GW in 2017, mostly generated from thermal power. Among all power generation, 46.6% was coal (125.93 gW), 4.7% was oil (12.76 gW), 34.6% was gas (93.41 gW), 8.3% was nuclear (22.45 gW), renewable energy was 4.6% (12.4 gW) and pumped-storage hydroelectricity was 1.2% (3.33 gW), as shown in Figure 1.6.1.

Table 1.6.1 Taiwan's Energy Supply Structure during 2001-2017 (by Energy Sector)

Unit: million kiloliters of oil equivalent

Year	Total Supply	Coal and coal produces	Oil and oil products	Natural Gas	Biomass and Wastes	Water	Nuclear	Solar, Geothermal, Wind and Biogas	Solar Thermal
2001	10,655	3,249	5,498	696	126	48.7	1,028	0.12	8.1
2002	11,163	3,444	5,625	779	135	26.6	1,145	0.16	8.4
2003	11,975	3,633	6,208	804	165	29.0	1,126	0.23	8.8
2004	13,279	4,000	6,950	978	167	30.7	1,144	0.25	9.3
2005	13,415	3,975	7,081	986	167	38.1	1,158	0.88	9.8
2006	13,683	4,122	7,129	1,058	169	39.1	1,155	2.65	10.2
2007	14,407	4,331	7,547	1,122	176	42.2	1,174	4.22	10.5
2008	13,929	4,219	7,071	1,220	180	41.2	1,182	5.67	11.0
2009	13,648	3,854	7,174	1,191	170	35.8	1,204	7.61	11.3
2010	14,308	4,224	7,161	1,479	178	40.1	1,206	10.06	11.4
2011	13,892	4,398	6,401	1,628	181	38.2	1,220	14.94	11.3
2012	14,169	4,253	6,772	1,709	184	54.2	1,171	15.17	11.4
2013	14,423	4,404	6,833	1,714	183	51.8	1,206	18.91	11.3
2014	14,859	4,394	7,184	1,803	179	41.3	1,228	19.62	11.2
2015	14,620	4,338	7,040	1,928	181	42.7	1,056	22.95	11.4
2016	14,669	4,304	7,172	2,003	174	62.7	917	24.75	11.2
2017	14,664	4,425	7,104	2,221	168	52.1	650	32.64	11.3

Source: MOEA Bureau of Energy, Monthly Report of Energy Statistics, November 2018

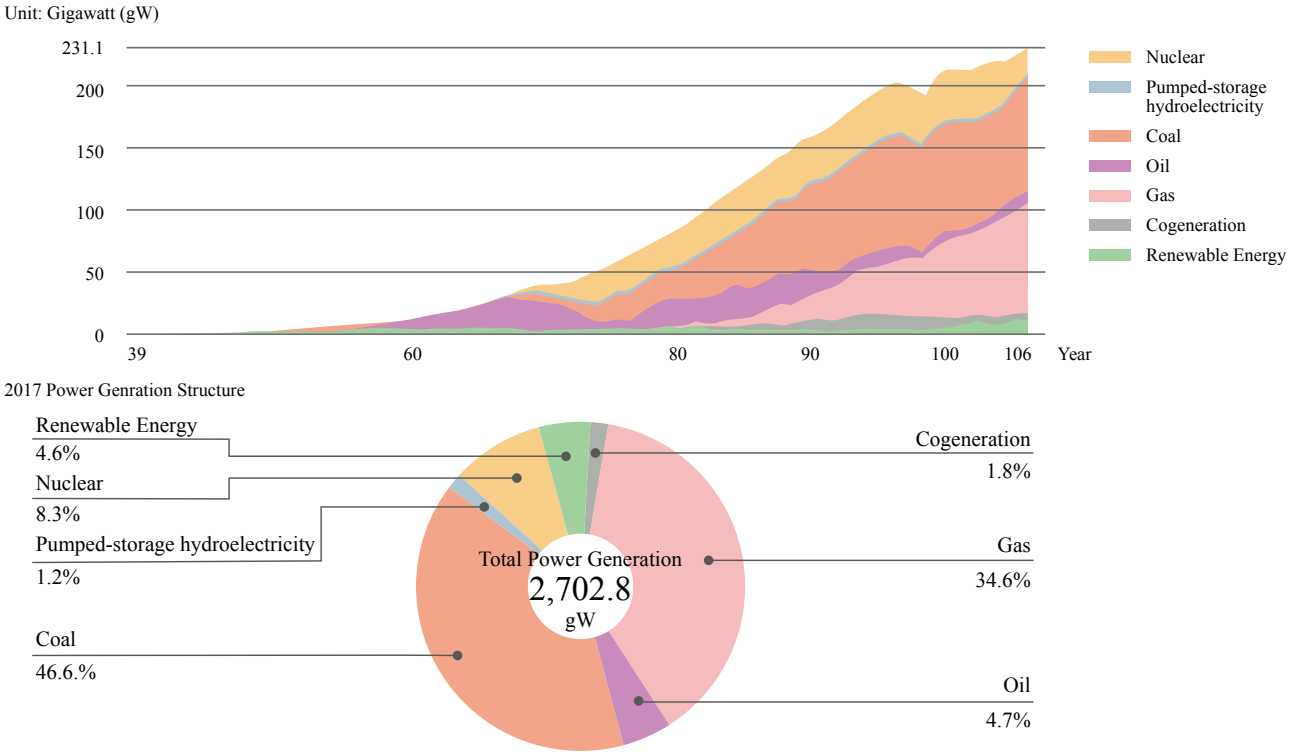


Figure 1.6.1 Taiwan's Power Generation Statistics and Structure by Year

Source: Taiwan Power Company, Electricity Supply and Demand Information and Development Plan-- Power Generation Statistics and Structure by Year, 2017

2. Energy Consumption

Taiwan's oil product consumption increased from 43,640 kiloliters of oil equivalents in 2012 to 45,230 kiloliters of oil equivalents in 2017. In the same year, liquefied natural gas imported accounted for 21,971,769 cubic kilometers, with a total consumption of 20,603,489 cubic kilometers. In regards to domestic energy consumption by sectors, self-served energy accounted for 6.88%, industrial sector 31.97%, transportation sector 16.13%, agricultural sector 0.76%, commercial sector 7.16%, residential building sector 7.73%, and non-energy consumption 29.35%.

3. Energy Efficiency Indicators

Taiwan's energy intensity continuously dropped since 2001. The average energy consumption per person increased slightly from 3,610.24 liters of oil equivalents in 2010 to 3,646.10 liters of oil equivalents in 2016. Taiwan's energy productivity was at 137.36 NTD/liter of oil equivalents in 2010, which gradually increased to 165.03 NTD/liter of oil equivalents in 2016. Therefore, as economic values created for energy use per unit grew, industrial energy efficiency also improved. Taiwan energy efficiency indicators are shown in Table 1.6.2.

Table 1.6.2 Taiwan Energy Efficiency Indicators

Item/ Year	Mid-year population	Average energy consumption per person	Domestic energy consumption elasticity value	Energy productivity (actual GDP/ domestic energy consumption)	Energy intensity (Domestic energy consumption/ actual GDP)	Average power usage
	(thousands)	(liter of oil equivalents/ person)		(NTD/liter of oil equivalents)	(Lliter of oil equivalents/ thousand NTD)	(degree/person)
2001	22,278.0	2,959.01	-6.14	137.36	7.28	8,101.90
2002	22,430.5	3,053.72	0.70	139.56	7.17	8,482.10
2003	22,562.8	3,207.94	1.38	137.51	7.27	8,884.75
2004	22,646.8	3,339.10	0.69	140.18	7.13	9,267.93
2005	22,729.8	3,368.16	0.23	145.97	6.85	9,611.08
2006	22,823.5	3,393.16	0.21	152.41	6.56	9,900.64
2007	22,917.4	3,580.04	0.91	153.24	6.53	10,188.16
2008	22,997.7	3,425.78	-5.64	160.70	6.22	9,987.33
2009	23,078.4	3,396.79	0.32	158.98	6.29	9,563.65
2010	23,140.9	3,610.24	0.62	165.03	6.06	10,259.10
2011	23,193.5	3,505.80	-0.70	176.02	5.68	10,437.58
2012	23,270.4	3,502.14	0.11	179.24	5.58	10,365.73
2013	23,344.7	3,602.12	1.45	177.54	5.63	10,499.47
2014	23,403.6	3,634.75	0.29	182.56	5.48	10,728.20
2015	23,462.9	3,631.94	0.22	183.71	5.44	10,655.94
2016	23,515.9	3,646.10	0.44	185.16	5.40	10,861.57
2017	23,555.5	3,619.68	-0.19	191.58	5.22	11,096.88

Source: MOEA Bureau of Energy, 2017 Annual Report of Energy Statistics, 2017

1.7 Transportation

Taiwan's transportation industry includes land, sea and air. The Ministry of Transportation and Communications (MOTC) administrates all aspects of transportation and communications within the Republic of China (Taiwan). Its operational duties are divided into four major categories: transportation, tourism, meteorology and communications. Land transport includes rail and road transport. Rail transport covers general railway, MRT and the high-speed rail system. Marine transportation covers shipping, ports and harbors. Air transportation contains airline companies and airports. Table 1.7.1 illustrates the volume statistics of transportation & communications from 2010 to 2017. The following sections introduce Taiwan's land, sea, and air transportation:

Table 1.7.1 Volume statistics of Transportation & Communications (2010-2017)

Year	Road length (kilometer)	Road surface area (hectare)	Motor vehicle		Operation statistics by motor carriers		Operation statistics by airlines		
			Registered numbers (thousands)	Intensity (vehicle/km^2)	Passenger-kilometer (million people/km)	Freight ton-kilometer (million ton/km)	Cycle count (thousands)	Passengers (thousands)	Freight tons (thousands)
2010	40,353	478,911	21,650	600	16,307	29,632	360	41,091	2,336
2011	40,995	483,006	22,226	614	17,040	29,551	385	42,856	2,179
2012	41,924	490,797	22,346	617	17,586	29,851	405	46,860	2,091
2013	42,520	501,392	21,562	596	17,928	38,474	427	50,336	2,085
2014	41,916	489,678	21,290	588	18,384	37,852	455	55,357	2,222
2015	41,950	490,042	21,400	591	17,565	37,805	481	58,156	2,151
2016	43,365	526,241	21,511	594	17,379	38,533	527	63,253	2,233
2017	43,206	532,555	21,704	599	17,053	40,351	509	65,979	2,416

Source: MOTC, Statistical Abstract of Transportation & Communications, 2017

1. Land Transportation

Land transportation mainly includes roads and railway. As of the end of 2017, the total road length, including national expressways, provincial roads, urban roads, county roads, district roads, township roads and exclusive highways in Taiwan, accounted 21,713.8 kilometers. Road intensity was 0.6 km per square kilometer. There are 9 national expressways, 48 main provincial roads, 50 branch provincial roads (as a total of 98 provincial roads), 148 urban and county roads, 2,354 district and township roads, and 36 exclusive highways.

The 2017 land transportation traffic volume statistics are shown in Table 1.7.2. Railways have been the lifeline of Taiwan's transportation over the century. As of the end of 2017, the whole line of Taiwan Railways Administration operated 228 stations. There are 1,065.0 kilometers of railway in Taiwan, including 723.8 kilometers of two-lane railway and 341.2 kilometers of single-lane railway. The 885.9 kilometers of electrified local trains include the main line, Nei-wan line between North Hsinchu and Zhuzhong, Liujia line, Taichung line, Shalun line, Pintung line between Kaohsiung and Pingtung, Yilan line, North Link line, Taitung line, and Hualien Port line. The rest of non-electrification local trains cover 179.1 kilometers. There are 4,328 railway vehicles, including 264 motor tractors, 2,373 passenger cars and 1,691 freight trains.

Table 1.7.2 Land transport traffic volume in 2017

Statictics Items				Unit	Numbers this year (2017)	Numbers last year (2016)	Increase or decrease comparison (or percentage) (%)
Railway	Taiwan Railway yearly passenger			million people	233	230	1.1
	Taiwan Railway Passenger-kilometer			million people/km	11,016	10,968	0.4
	Use of passenger seats	Tze-Chiang Limited Express		%	70.9	70.3	0.6
		Chu-Kuang Express		%	43.4	42.9	0.5
		Local Train		%	64.3	61.9	2.4
		Ordinary Train		%	20.3	11.4	8.8
	Taiwan Railway yearly freight ton			10 thousand tons	776	922	-15.8
	Taiwan Railway freight ton-kilometer			million ton/ km	512	562	-8.9
	MRT yearly passenger			million people	82,773	80,309	3.1
	MRT Passenger-kilometer			million people/km	6,871	6,480	6.0
High Speed Railway	High Speed Railway yearly passenger			10 thousand people	6,057	5,659	7.0
	High Speed Railway passenger-kilometer			million people/km	11,103	10,488	5.9
Road	Road Length			Kilometer	43,206	43,365	-0.4
	Yearly total passenger	Passenger number		million people	1,235	1,225	0.8
		Passenger-kilometer		million people/km	17,053	17,379	-1.9
	Urban car passenger	Passenger number		million people	1,093	1,057	3.4
		Passenger-kilometer		million people/km	9,342	8,988	3.9
	Road car passenger	Passenger number		million people	142	168	-15.8
		Passenger-kilometer		million people/km	7,711	8,390	-8.1
	Road car freight	Fright tons		million tons	537	530	1.3
		ton/ km		million ton/ km	40,351	38,533	4.7
	Express way	Passing vehicles	Total	10 thousand vehicles	591,902	579,103	2.2
			Light car	10 thousand vehicles	519,347	507,673	2.3
			Large vehicle	10 thousand vehicles	41,525	40,919	1.5
			Trailer	10 thousand vehicles	31,030	30,511	1.7
	Motor vehicles registration number (categorized by types)	Total		thousand vehicles	21,704	21,511	0.9
		Large passenger vehicle		thousand vehicles	34	35	-1.0
		Truck		thousand vehicles	167	167	0.1
		Small passenger vehicle Van		thousand vehicles	6,763	6,666	1.5
		Small Truck		thousand vehicles	919	912	0.9
		Special purpose vehicle		thousand vehicles	65	63	2.2
		Scooters		thousand vehicles	13,756	13,668	0.6
	Motor vehicles registration number	Vehicles		thousand vehicles	7,949	7,842	1.4
		Scooters		thousand vehicles	13,756	13,668	0.6
	Average motor vehicles number owned by hundred people			Vehicle/ hundred people	92.1	91.4	0.8

Source: MOTC, Statistical Abstract of Transportation & Communications, 2017

The North-South high-speed railway consists of a total of 350 kilometers from the north end of Taipei Nangang Station to the south end of Kaohsiung Zuoying Station. It greatly shortens the travel time between the north and the south and collaborates with the available external transportation system of the high-speed railway station to gradually build a one-day living circle in western Taiwan.

The Metro System is essential for public transportation in Taiwan's metropolitan area. The opening of the Taipei and Kaohsiung Metro System has dramatically changed people's lifestyle, with the Taichung Metro and Taiwan Taoyuan International Airport Linked to MRT. After the completion of the system construction, the system will provide a fast and convenient public transportation service for the core urban metropolitan area.

2. Sea Transportation

Taiwan is surrounded by the sea, while international trade and maritime transportation play a crucial role in Taiwan's economic and trade development. The international business routes cover ship transportation industry and international cruise tourism.

The round-the-island transshipment route develops the third transport corridor. The airliners handle their own cargo-to-island transshipment operations on their own or operated vessels. The container transportation is shifted from land transport to sea transport, effectively mitigating the "Northern Cabinet South" or land traffic congestion issues such as the "Southern Cabinet North Transportation".

In order to effectively utilize Taiwan's port resources, reduce industrial transportation costs and improve the service level and international competitiveness of the ports, the Executive Yuan approved the "International Business Port Future Development and Construction Program" (2017-2021) in 2016 and continued to promote Kaohsiung Port Intercontinental Container Center Phase II project and other major harbors constructions. In terms of freight transportation, Taiwan's port group will be integrated to build a global shipping network, where passenger transportation will combine with local tourism resources to actively strengthen cruise transportation facilities while promoting the green port as an important policy direction for future port sustainable development.

3. Air Transportation

There are currently 7 civil air transportation companies operating domestic and international regular routes in Taiwan. The civil aviation industry is highly related to the overall economic development. The government is actively supporting the development of air transportation and expanding the operating opportunities and rights of way through negotiations and consultations. Currently, Taiwan has signed air routes with 57 countries or regions, operating 211 global scheduled passenger routes and 85 cargo routes, totaling 296 routes and connecting 141 cities around the world. The international routes of various airports in Taiwan have benefited from the tourism boost in recent years and the number of passengers continues to grow.

1.8 Industry

The Executive Yuan has proclaimed the industrial development program in line with Article 4 of the Industrial Innovation Regulations on May 9, 2011, to promote the all-round innovation and development of the industry with the development trend and challenges of international industry

and to pay attention to the balance of national industrial development. The three visions of "improving international economic and trade status," "transforming a diversified industrial structure" and "promoting regionally balanced development" reveal the development direction of Taiwan's agriculture, industry and services in the following decade.

Central government agencies set up the direction of industrial development and plans under the framework of the “Industrial Development Program” for the responsible industries. To accelerate upgrading the industry, the Government is actively promoting visions of industrial innovation such as "Asia Silicon Valley," "Smart Machinery," "Green Energy Technology," "Biotechnology", "Defense," "New Agriculture," and "Circular Economy." As the core of the growth of Taiwan's next-generation industry, the government will achieve the vision of digital countries, smart islands, service industries, non-nuclear homes and energy conservation and carbon reduction.

Taiwan will continue promoting the development of the smart machinery industry, green energy technology industry, Asia · Silicon Valley, and the industrial chain energy of the industry alliance following a soft and hard integration. Furthermore, Taiwan will continue assisting in the establishment of "Asia · Silicon Valley Grain Networking Industry Alliance" and promoting the biomedical industry, the defense industry and the rise of the backbone enterprises. The integration of various ministries will include resources for mentoring, such as talents, technology, intellectual property and brand marketing, to assist potential enterprise companies to use government funds to create jobs and promote traditional industry guidance.

1.9 Wastes

In the early days of Taiwan's waste treatment policy, landfill was the main way of treatment. Waste treatment policy has significantly changed with the awareness of land use, environmental protection and resource recycling. From the "large incinerator installation" in 1990, the "four in one resource recovery" in 1997, the "zero waste disposal" in 2004, the "mandatory recycling" in 2005, to the waste treatment now, Taiwan is further strengthened with the "sustainable material management" since 2011. Taiwan's waste treatment has been gradually recycled the past the recycling of resources while the final disposal of waste decreases continuously.

According to the 2018 Republic of China Environmental Protection Statistics Annual Report, Taiwan's waste cleanup in 2017 can be divided into incineration, landfill, dumping, resource recovery, huge waste recycling and food waste recycling. The waste production volume is 7,870,896 metric tons, of which 4,133,098 metric tons accounted for recycling, the highest point achieved at 52.5%, while incineration accounted for 37.7% and the third position for kitchen waste recovery represented 7.0%. The burial was divided into "sanitary" and "general," while sanitary burial was properly managed waste burial. Landfill treatment only accounts for 0.9%, including general burial and resource recovery

The treatment of domestic sewage, through sewage construction plan, is prioritized by promoting the recycling of waste sludge and discharge water from sewage treatment plants, increasing the user acceptance rate every year, and properly handling them to reduce public health and water pollution. The operation unit of the relevant treatment plant will be built according to the characteristics of wastewater. In

recent years, with more rigorous emission standards of the water pollution prevention and control law imposed and the economic recovery capacity increased, the GHG emissions of the relevant business wastewater will also grow accordingly.

1.10 Buildings and Urban Structure

The construction business is highly related to the country's urbanization, economic development, citizens' quality of life and improvement of the living environment. The specific goals aim to establish a fair and efficient system of construction management and sustainable development of the industry, create a high-quality production and living environment, implement the development planning, conservation and sustainable use of the land and living space and pursue regional and urban-rural equilibrium. Furthermore, Taiwan is focused on developing and building a modern city with local characteristics.

Faced with global climate change challenges and resource scarcity, the Ministry of the Interior (MOI), as the building regulatory authority, has formulated a building energy conservation regulation in 1995 to ensure that the country a healthy and comfortable living environment with sustainable energy conservation. The "Green Building Marking System established in 1999 "is aimed at Taiwan's subtropical high-temperature and high-humidity climate characteristics, with Ecology, Energy Saving, Waste Reduction and Health, which are energy-saving, environmentally friendly and ecological. The Sustainable Green Building Mark Evaluation (EEWH) system is not only the fourth green scale assessment system in the world for scientific implementation but also the first in independent development of tropical and subtropical high temperatures and countries with high humidity climates. Even more significantly, since July 2017, the application for certification of overseas green building stamps has been officially accepted and the tangible national border has been extended to enlarge the scope of Taiwan Green Building Certification, which fulfills the obligations and responsibilities of international citizens for the global environmental protection.

1.11 Agriculture, Forestry, Fishery and Husbandry

1. Agriculture Production

In 2017, Taiwan's agricultural production value accounted NTD 546.5 billion, and agricultural GDP was NTD 300.4 billion, representing 1.72% of gross domestic product GDP, which was significantly low compared to the rapid development of the non-agricultural sector. The output value of agriculture, forestry, fishery and husbandry and the proportion of total agricultural output were as follows: agricultural products totaled NTD 292.1 billion, accounting for 53.4%; livestock and poultry products totaled NTD 163.9 billion, representing 30.0%; fishery products totaled NTD 90.4 billion, accounting for 16.5%; forest products totaled NTD 0.17 billion, not even reaching 0.1% of the total output. Figure 1.11.1 shows the proportion of agriculture, forestry, fishery and, husbandry.

In terms of agricultural land use, the farmed land area in Taiwan was 793,000 hectares in 2017, accounting for 21.9% of the total area of the country. The largest agricultural area for crops was rice, with a total planted area of approximately 270,000 hectares, and the cultivated area of fruit trees was close to 13.0. The following is the result of 10,000 hectares of vegetables and miscellaneous grains, and the planted area is about 63,000 and 57,000 hectares respectively.

The top three products by the output value of animal husbandry in Taiwan are pigs (46.1%), chickens (24.0%) and eggs (11.5%). In terms of livestock and by-product production, the number of pigs slaughtered was 7.947 million with an output was 811,000 metric tons. The number of chicken slaughters was 340 million with an amount of 555,300 metric tons. The total production of eggs reached 7.5 billion.

The production structure of Taiwan's agriculture has changed in recent years. The area of cultivated land and the number of livestock and poultry farming show a decreasing trend. The area of cultivated land has dropped from 815,000 hectares in 2009 to 793,000 hectares in 2017 and the number of pigs has decreased from 6.13 million in 2009 to 5.43 million at the end of 2017. The GHG emissions of the agricultural sector have also shown a decreasing trend.

2. Forestry and Natural Conservation

In response to management operation needs, the Forestry Bureau has conducted investigations of various scales, including national forest resource investigations, permanent forest sample plot investigations and state-owned forest working circle revision investigations. The 4th National Forest Resource Investigation, completed in 2014, showed that the forest area of Taiwan (including Kinmen and Lianjiang Counties) was estimated to be 2.197 million hectares, with forest coverage of 60.71%. Among which, the forest land defined by the Forest Law and the forest cover area is 1,781,660 hectares. Other lands, except forest land, cover an area of 415,430 hectares. The forest area was 0.092 hectare per capita. The total forest area of the island is 1,993,205 hectares, according to ownership, 1,849,818 hectares were state-owned forests, accounting for 92.8%; 6,832 hectares were public forests, accounting for 0.3%; and 136,555 hectares were private forests, accounting for 6.8%.

In terms of forest type, the predominant type was broadleaf forests, estimated at 1,469,898 hectares, accounting for 67% of forest areas. Coniferous forest areas were estimated at 299,216 hectares, representing 14% of the country's forest areas. Mixed coniferous and broadleaf forests covered an area of 171,346 hectares, accounting for 8% of the total forest areas. Bamboo forest had an area of 112,548 hectares, accounting for 5% (as shown in Figure 1.11.2).

The total forest stock volume was 502 million cubic meters with about 1.58 billion bamboo poles, which represent 754 million tons of total carbon storage.

The total timber production volume was 26 thousand cubic meters in 2017 with a value of 0.1 NTD billion. In parallel, there were about 1.17 million bamboo poles with a value of 1.1 NTD billion.

At present, the domestic use of wood is highly dependent on imports, and the development of plantation forests is dominated by private forests, supplemented by state-owned forests. The current policy goal is to promote the sustainable operation and utilization of domestic resources, gradually providing domestic production with stable sources and quantities, and to explore the market demand for domestic wood and bamboo products for promoting the development of forestry industry.

The "Strategic Plan for National Spatial Development" approved by the Executive Yuan aspires to promote the view of a continuous ecological corridor, given the composition of mountainous areas at an altitude of 1,500 meters above the national

park to protect the country's rare resources. The government has classified the national protected areas in 6 different types: natural reserves, wildlife refuges, major wildlife habitats, forest reserves, national parks and national nature parks. At present, there are 22 natural reserve areas designated by the Cultural Heritage Preservation Act; 20 wildlife refuges and 37 major wildlife habitats recognized under the Wildlife Conservation Act; 6 forest reserves have been announced to be established under The Forestry Act; and 9 national parks and 1 National Natural Park are announced to be also established under the National Park Law of the Ministry of the Interior (MOI). Taiwan's protected areas sum up 95 with various types of protected areas, with an extension of approximately 1,133,490 hectares (excluding duplicates), and a land area of 694,503 hectares, accounting for approximately 19.19% of Taiwan's land area.

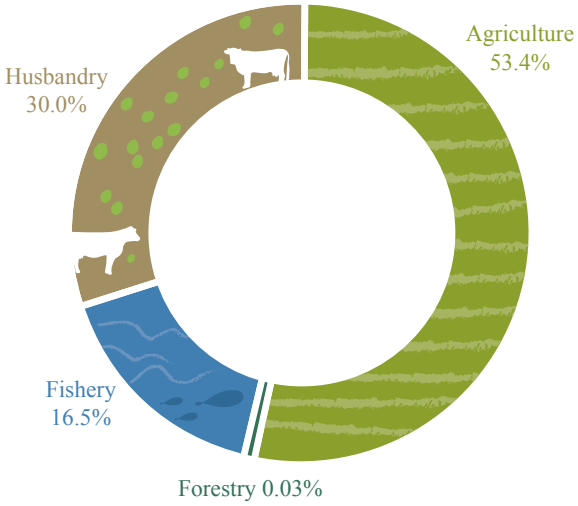


Figure 1.11.1 Proportion graph of production value of Taiwan's Agriculture, Forestry, Fishery and Husbandry in 2017

Source: Council of Agriculture (COA) Executive Yuan ROC, 2017 COA Annual Report, March 2018

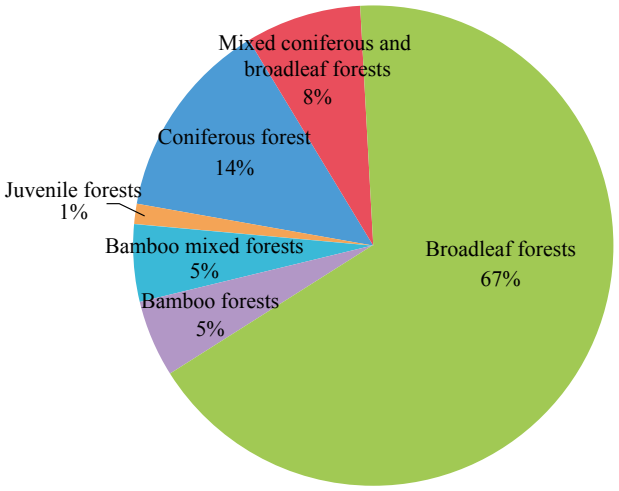


Figure 1.11.2 Taiwan's Current Status of Forest Types

Source: Forestry Bureau of the Council of Agriculture (COA) Executive Yuan ROC, The Fourth Forest Resource Survey, 2015

Reference

1. Website of the Executive Yuan ROC Taiwan, Introduction on ROC Taiwan's National Profile: http://www.ey.gov.tw/state/default.aspx
2. Website of the Executive Yuan ROC Taiwan, Structure & Functions: https://www.ey.gov.tw/Page/62FF949B3DBDD531
3. Website of Ministry of the Interior ROC Taiwan, Department of Civil Affair's Introduction of local administration area: https://www.moi.gov.tw/dca/02place_002.aspx
4. National Development Council, "Population Projections for R.O.C. (Taiwan): 2018~2065", August 2018
5. Website of National Statistics ROC Taiwan, Statistics of Nationale GDP and economy growth: https://www.stat.gov.tw/ct.asp?xItem=37407&CtNode=3564&mp=4
6. Website of Department of Irrigation and Engineering, History of Irrigation in Taiwan: http://doie.coa.gov.tw/history_detail.php?tid=2&l=2&cid=7#7
7. Website of the Executive Yuan ROC Taiwan, Introduction on ROC Taiwan's National Profile-National spatial and urban and rural Development: http://www.ey.gov.tw/state/default.aspx
8. Website of the Central Weather Bureau, Taiwan's temperature trend: https://www.cwb.gov.tw/V7/climate/climate_info/taiwan_climate/taiwan_2/taiwan_2_1.html
9. Ministry of Economic Affair Bureau of Energy, Monthly Report of Energy Statistics, November 2018: https://www.moeaboe.gov.tw/ECW/populace/web_book/WebReports.aspx?book=M_CH&menu_id=142
10. Ministry of Economic Affair Bureau of Energy, 2017 Energy Statistics Report, 2017
11. Taiwan Power Company, Electricity Supply and Demand Information and Development Plan-- Power Genration Statistics and Structure by Year, 2017
12. Website of National Statistics ROC Taiwan, Updated statistics indicators- population: https://www.dgbas.gov.tw/point.asp?index=9
13. Minstry of Transportation and Communication, Statistical Abstract of Transportation & Communications, 2017: https://www.motc.gov.tw/ch/home.jsp?id=59&parentpath=0,6
14. Executive Yuan Environmental Protection Administration, 2018 Statistics Report of Republic of China Taiwan, 2018
15. Executive Yuan Council of Agriculture (COA), Annual Statistics Report on Agriculture, June 2018: http://agrstat.coa.gov.tw/sdweb/public/book/Book.aspx
16. Executive Yuan Council of Agriculture (COA), 2017 COA Annual Report, March 2018: https://www.coa.gov.tw/ws.php?id=2508377
17. Executive Yuan COA Forestry Bureau, The 4th National Forest Resource Investigation, 2015

▲Gaomei Wetland

Chapter 2
Greenhouse Gas Emission Statistics and Trend Analysis

Chapter 2
Greenhouse Gas Emission Statistics and Trend Analysis

Statistics and trend analysis of greenhouse gas (GHG) emissions and absorptions in Taiwan are mainly presented in the "greenhouse gas inventory." The statistics GHG emissions and removals are compiled by the inventories of different sectors. The statistical results of GHG emissions by sector submitted by the Bureau of Energy and the Industrial Development Bureau of the Ministry of Economic Affair (MOEA), the Council of Agriculture (COA) and the Environmental Protection Administration (EPA) of the Executive Yuan and other central authorities in charge of the relevant industries, are compiled following the statistical method specified in the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories released by the IPCC.

2.1 GHG inventory method and statistical procedure

Regarding Taiwan's GHG inventory, the statistics of GHG emissions and removals are produced by the inventories of different sectors. The statistical results of GHG emissions by sector submitted by the MOEA Bureau of Energy and Industrial Development Bureau, the COA and the EPA of the Executive Yuan, and other central authorities in charge of the relevant industries, are compiled based on the statistical method specified in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories released by the IPCC.

The data are submitted to the National Greenhouse Gas Emissions Inventory Review Council for discussion after various relevant ministries have written down the counts and deliberations while compiled by the EPA of the Executive Yuan. Experts and academics in related fields are invited to proofread the manuscripts to ensure the correctness and consistency of the contents of the report. According to Article 13 of the Greenhouse Gas Reduction and Management Act, annual emission statistics are published to the public, as shown in Figure 2.1.1.

The following part is a brief description of the sources of GHG inventories:

1. Energy sector

The classification principles of the energy sector and fuels are the same as those prescribed in the 2006 IPCC Guidelines. The calculation methods of GHG emissions have different computing levels according to the data classification method. Tier 1 method involves energy supply and demand data. Tiers 2 and 3 use technical data to do the calculations. The calculation of carbon dioxide (CO_2) is based on the reference method and the sectoral method of the 2006 IPCC Guidelines. For other non- CO_2 GHGs, the emission coefficient is used to estimate the emission value. Since gas emissions depend on fuel type, detailed technical data on the combustion technology, operation, control technology, maintenance and new and old equipment are required. Consequently such data are not listed in the Tier 1 method. The activity data of Taiwan's energy sector GHG emission inventory statistics are based on the energy balance sheets published by the MOEA Bureau of Energy. Additionally, the carbon emission factors (CEF), the fraction of carbon oxidized and the fraction of carbon stored calculated by the sector mainly refer to the default value of the 2006 IPCC Guidelines.

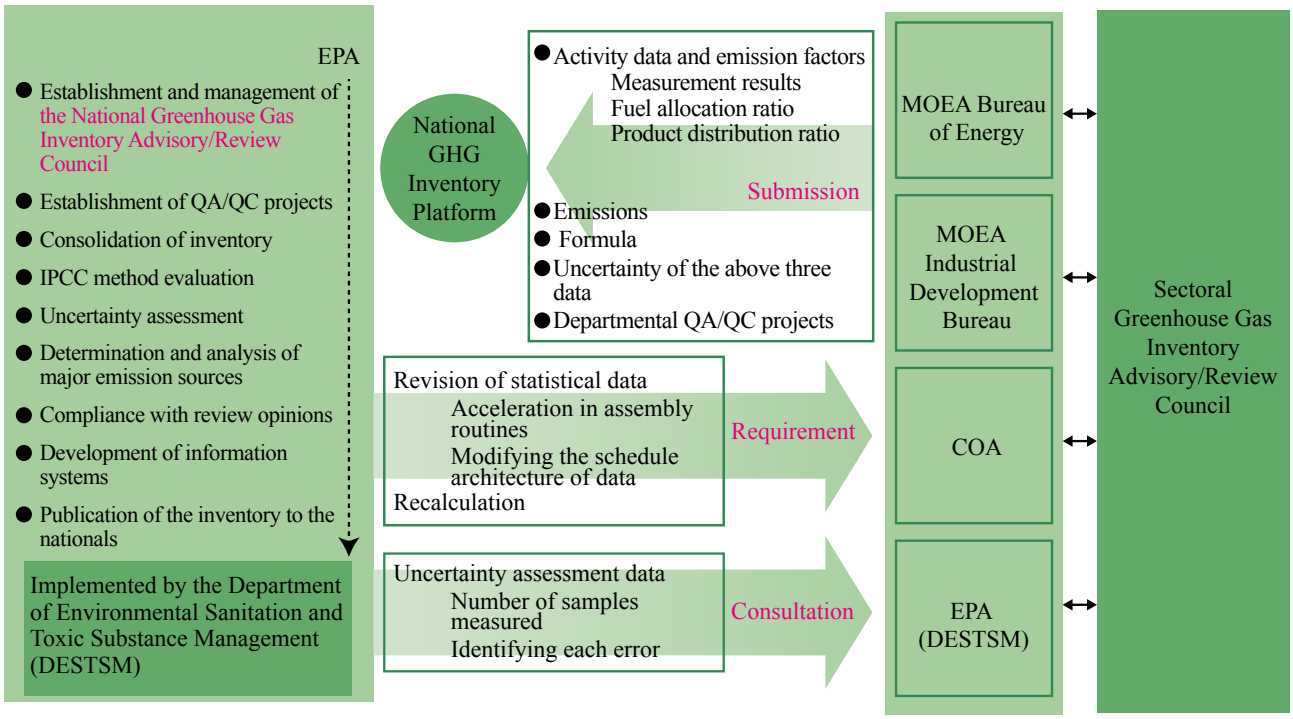


Figure 2.1.1 Taiwan national GHG inventory preparatory procedure

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

2. Industrial processes and product use sector

According to the 2006 IPCC Guidelines, the principal sources of GHG emissions (e.g. high converter billet process, integrated circuit and semiconductor process, and thin film transistor liquid crystal display (LCD) process) in Taiwan's industrial process and product use sectors have been gradually changed to Tier 3 method for statistics. That is to say, the inventory of domestic manufacturers is used for statistics. The process of data statistics verified by a third party is characterized by low uncertainty. The category of statistics is confirmed with the business sector before adopting it to confirm the consistency of statistics with facts and eliminate the possibility of repeated calculation. Moreover, the tier 1 method is adopted for compiling statistics, while activity data are mainly the data under government statistical bulletin. Activity data have reliability, small error rates and are constant. The emission coefficient is calculated by referring to the preset coefficient provided by the 2006 IPCC guidelines or by the emission coefficient established by the measurement method of the industry.

3. Agricultural sector

Statistical data of Taiwan's agricultural sector were cited from the “Taiwan Agricultural Yearbook" issued by the Department of Agriculture and Forestry of the Taiwan Provincial Government between 1990 and 1999. In 2000, due to the downsizing of Taiwan provincial government, the COA of the Executive Yuan started to incorporate it in the Agricultural Statistics Yearbook. Taking into consideration that emission factors are predominantly local values reported, the values recommended in the 2006 IPCC Guidelines are used for those lacking.

4. Land use, land use change and forestry sector

When estimating GHGs in the forestry sector, due to incomplete forest resources and land use surveys and forestry statistics in Taiwan, the data available and summarized in Taiwan are classified and calculated only based on the 2006 IPCC Guidelines. The correlation coefficient is reliant on Taiwan's research value. If Taiwan does not have this value, the preset value of the 2006 IPCC Guidelines will be used. In the 2006 IPCC Guidelines, dead organic matter (DOM) considers that the change of carbon storage is not obvious, so it can be assumed to be 0, i.e. the input is equal to the loss. Because Taiwan is still in the process of soil classification and estimation, the current data of the soil is insufficient to complete the statistical work.

5. Waste sector

When the waste sector calculates GHG emissions, the activity data cited on solid waste disposal, wastewater, waste incineration and open burning and other waste management are derived from the government's "Official Yearbook of Environmental Statistics", biogas recovery data, incinerator data, water pollution source control data management systems, business waste control information networks, served rates of sewers, and discharge from food balance sheets.

2.2 Various GHG emissions and removal statistics

As of 2016, the latest statistics of GHG emissions in Taiwan totaled about 293,125 thousand tons of CO_2 equivalent (Gg CO_2eq), of which 279,216 Gg CO_2eq (excluding CO_2 removal) accounted for 95.26% of the total GHG emissions. Others included methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), nitrogen trifluoride (NF_3), and so on. The emission of CO_2 from fuel combustion in the energy sector made up 94.07% of the total CO_2 and 89.61% of the total GHG. Taiwan's share of GHG emissions in 2016 is shown in Figure 2.2.1.

Taiwan's total GHG emissions rose from 138,097 Gg CO_2eq (excluding CO_2 removal) in 1990 to 293,125 (excluding CO_2 removal) in 2016, with an increase of 112.26% and an average annual growth rate of 2.94%. Emissions between the year 2015 and 2016 increased by 0.92% from 290,451 Gg CO_2eq (excluding CO_2 removal) in 2005 and grew at an average annual rate of 0.08%. Between 2016 and 2015, it increased by 1.22%. Net GHG emissions rose from 114,711 Gg CO_2eq in 1990 to 271,707 in 2016, with an increase of 136.86% and an average annual growth rate of 3.37%. Emissions from 2005 accounted for 268,533 Gg CO_2eq (excluding CO_2 removal), and increased by 1.18% in 2016, with an average annual growth rate of 0.11%. In 2016, it climbed by 1.32% compared with 2015, as shown in Figure 2.2.2 and Table 2.2.1.

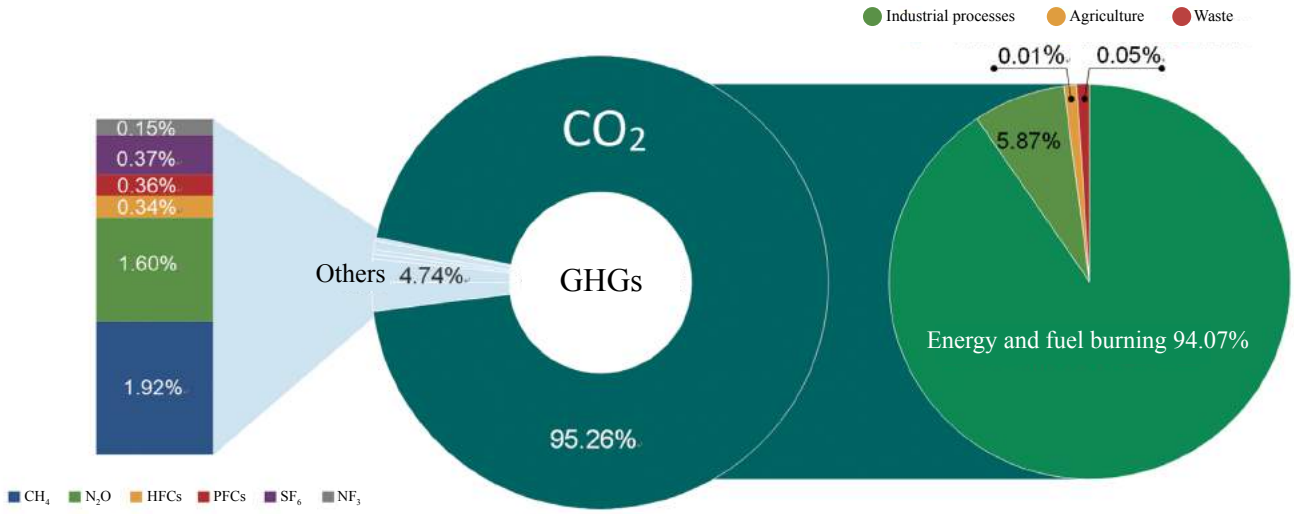


Figure 2.2.1 Proportion of GHG emissions in 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

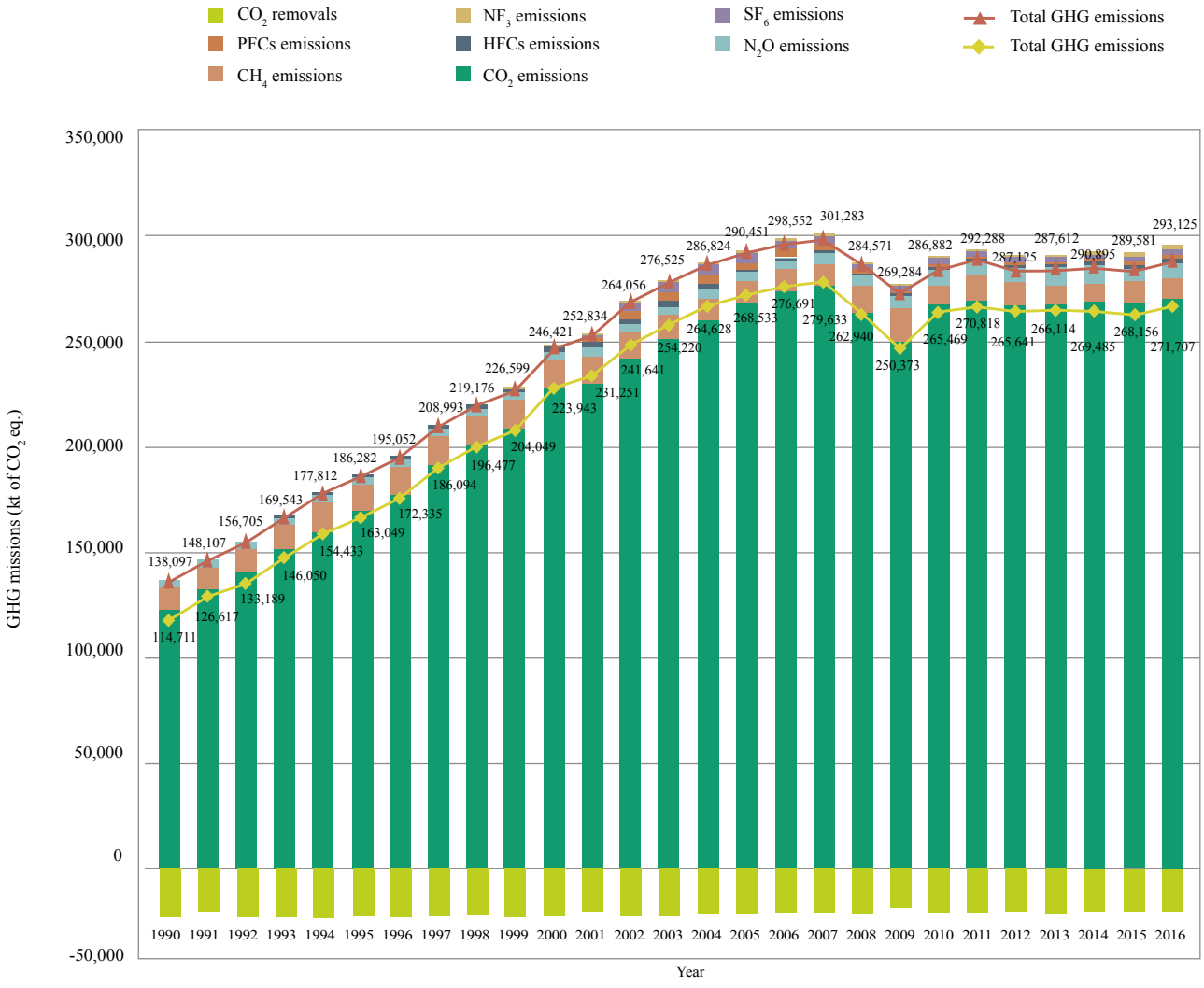


Figure 2.2.2 Trends in total GHG emissions and removals in Taiwan from 1990 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.2.1 GHG emissions and removal in Taiwan from 1990 to 2016

(Unit: kt of CO_2 eq.)

GHG	GWP	1990	1991	1992	1993	1994	1995	1996	1997	1998
CO_2	1	124,045	133,565	142,151	153,771	161,139	168,854	176,761	190,526	200,140
CH_4	25	11,158	11,394	11,411	11,804	12,562	13,297	13,730	13,703	13,724
N_2O	298	2,895	3,148	3,143	3,213	3,257	3,329	3,255	3,287	3,229
HFCs	HFC-134a: 1,430	NE	NE	NE	755	855	801	1,305	1,477	2,083
PFCs	PFC-14:7,390	NE	NE	NE	NE	NE	NE	NE	NE	NE
SF_6	22,800	NE	NE	NE	NE	NE	NE	NE	NE	NE
NF_3	17,200	NE	NE	NE	NE	NE	NE	NE	NE	NE
CO_2 removal	1	-23,386	-21,490	-23,516	-23,493	-23,379	-23,233	-22,717	-22,899	-22,699
Net GHG emissions		114,711	126,617	133,189	146,050	154,433	163,049	172,335	186,094	196,477
Total GHG emissions		138,097	148,107	156,705	169,543	177,812	186,282	195,052	208,993	219,176
GHG	GWP	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2	1	207,804	227,011	230,089	237,658	249,730	259,449	266,619	275,886	279,586
CH_4	25	13,865	13,146	12,346	11,770	11,298	10,610	10,102	9,463	8,967
N_2O	298	3,192	3,802	3,860	3,957	3,977	4,122	4,181	4,713	4,792
HFCs	HFC-134a: 1,430	1,609	2,319	2,619	2,216	2,397	2,451	1,070	987	1,093
PFCs	PFC-14:7,390	3	13	2,939	4,143	4,198	4,341	3,070	3,264	2,972
SF_6	22,800	116	120	746	3,914	4,385	5,193	4,683	3,590	3,114
NF_3	17,200	11	10	235	398	540	659	726	650	759
CO_2 removal	1	-22,550	-22,476	-21,583	-22,415	-22,305	-22,196	-21,918	-21,861	-21,650
Net GHG emissions		203,584	223,945	231,251	241,641	254,220	264,628	268,533	276,691	260,412
Total GHG emissions		226,134	246,421	252,834	264,056	276,525	286,824	290,451	298,552	282,043
GHG	GWP	2008	2009	2010	2011	2012	2013	2014	2015	2016
CO_2	1	266,377	252,237	270,134	276,166	272,332	272,618	276,235	275,634	279,216
CH_4	25	8,279	7,662	7,134	6,756	6,437	6,060	5,878	5,676	5,637
N_2O	298	4,377	4,547	4,953	4,850	4,767	4,569	4,558	4,516	4,701
HFCs	HFC-134a: 1,430	1,046	980	934	1,016	869	981	1,010	982	991
PFCs	PFC-14:7,390	1,682	1,143	1,354	1,365	725	929	1,139	931	1,045
SF_6	22,800	2,644	2,176	2,155	1,755	1,647	1,722	1,447	1,217	1,094
NF_3	17,200	166	538	219	381	349	734	627	623	440
CO_2 removal	1	-21,631	-18,911	-21,413	-21,470	-21,484	-21,498	-21,410	-21,425	-21,418
Net GHG emissions		262,940	250,373	265,469	270,818	265,641	266,114	269,485	268,156	271,707
Total GHG emissions		284,571	269,284	286,882	292,288	287,125	287,612	290,895	289,581	293,125

Note: NE (not estimated) means that there is no estimate of existing emissions and removals

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Analysis of variations in GHG emissions and removals from 2005 to 2016:

- CO_2: From 2005 to 2016, CO_2 grew 4.72%, with an average annual growth rate of 0.42%. From 2005 to 2016, the removal of carbon sinks decreased by 2.28%, with an average annual growth rate of -0.21%.
- CH_4: From 2005 to 2016, CH_4 fell 44.19%, with an average annual growth rate of -5.16%.
- N_2O: From 2005 to 2016, N_2O grew 12.43%, with an average annual growth rate of 1.07%.
- SF_6, PFCs, HFCs, and NF_3: From 2005 to 2016, SF_6, PFCs, HFCs, and NF_3 went down 62.61%, with an average annual growth rate of - 8.56%.
- The following describes the general situation and trends of GHG emissions:

1. Carbon dioxide (CO_2)

The energy sector was the primary source of CO_2 emissions in Taiwan. Table 2.2.2 lists the emissions and removal of CO_2 from 1990 to 2016 by Taiwan's various sectors. The emission trend is displayed in Figure 2.2.3. Taiwan's CO_2 emissions in 1990 were 124,045 kt of CO_2eq, 266,619 in 2005, and 279,216 in 2016. Among which, the energy sector in 2016 accounted for 94.07%, including 61.72% for the energy industry, 15.82% for the manufacturing and construction industries, 13.18% for the transportation industry, and 3.34% for other sectors (service, and housing, and agriculture, forestry, fishery and animal husbandry). Additionally, the industrial process and product use sector represented 5.87%, the agricultural sector accounted for 0.01% and the waste sector for 0.05%. In 2016, emissions grew 4.72% in 2005, mainly due to an increase of 5.77% in the energy sector. The removal of CO_2 from land use, land use change and forestry activities were 21,418 kt of CO_2eq in Taiwan in 2016, which was 8.42% lower than that of 23,386 in 1990. If compared with 2005, it decreased by 2.28% and 0.03% compared with 2015.

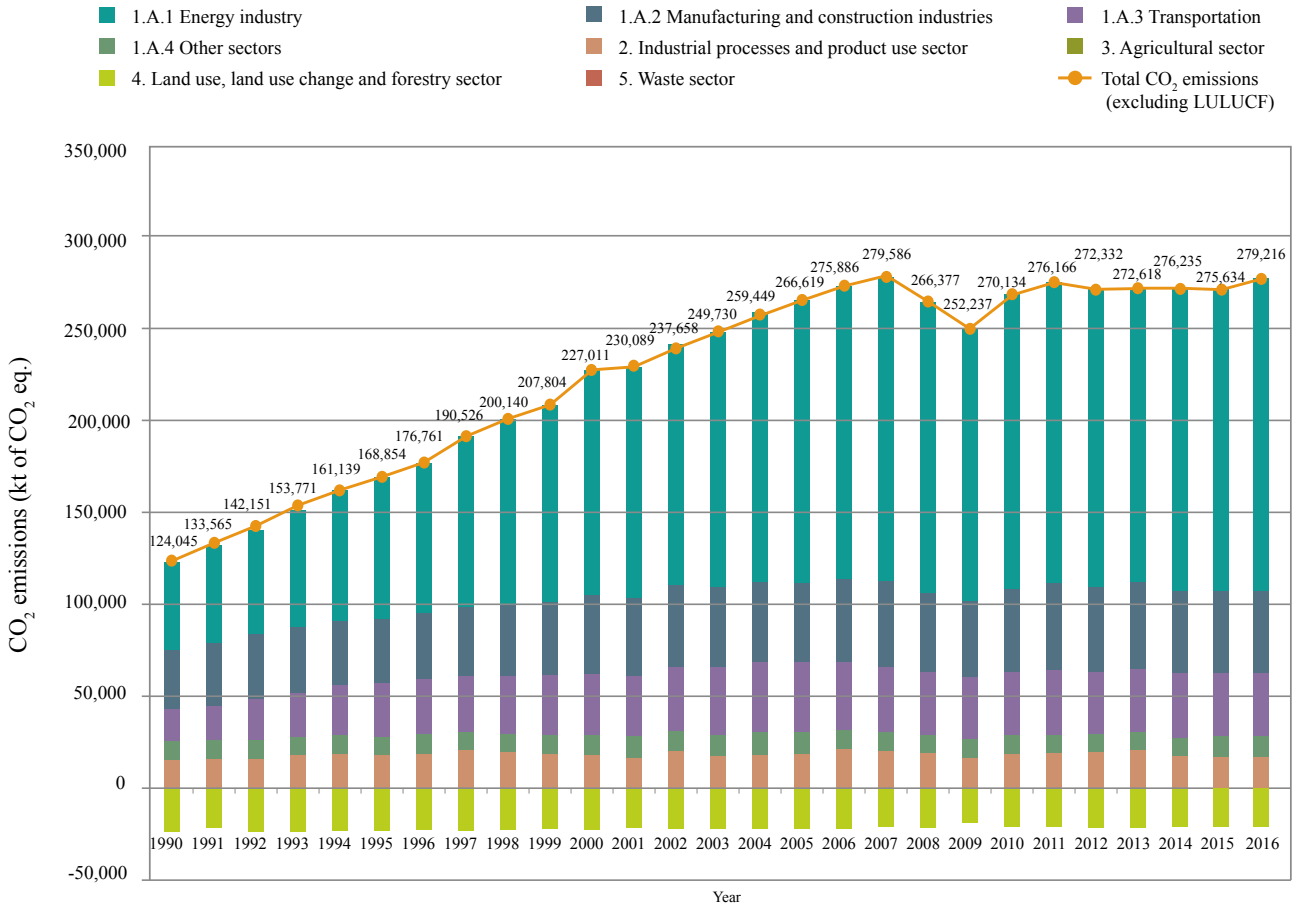


Figure 2.2.3 Trends in CO_2 emissions in Taiwan from 1990 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report

Table 2.2.2 CO_2 emissions in Taiwan from 1990 to 2016

(Unit: kt of CO_2 eq.)

GHG emission sources and absorption sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998
1. Energy sector	109,459	118,436	126,052	135,199	143,097	150,804	158,573	170,828	181,511
1.A.1 Energy industry	49,123	55,126	58,529	65,962	70,771	76,400	81,254	91,407	100,415
1.A.2 Manufacturing and construction industries	30,117	31,956	33,383	33,611	34,586	35,763	36,785	39,075	39,311
1.A.3 Transportation	19,646	20,888	24,033	26,103	27,540	28,822	29,801	30,536	31,844
1.A.4 Other sectors	10,572	10,466	10,107	9,523	10,200	9,820	10,733	9,809	9,940
1.A.4.a Service industry	3,621	3,529	2,989	2,490	3,018	2,445	3,175	2,483	2,947
1.A.4.b Housing	4,005	4,238	4,446	4,359	4,461	4,597	4,754	4,851	4,952
1.A.4.c Agriculture, forestry, fishery, and animal husbandry	2,946	2,700	2,672	2,675	2,721	2,777	2,805	2,475	2,041
2. Industrial processes and product use sector	14,424	14,975	15,895	18,378	17,797	17,501	17,651	19,460	18,386
2.A Mining (non-metallic products)	10,584	10,698	11,854	13,879	13,259	12,766	12,645	13,394	11,564
2.B Chemical industry	563	539	565	609	762	850	992	1,020	1,003
2.C Metal industry	3,275	3,735	3,474	3,888	3,774	3,884	4,013	5,045	5,817
2.H Other	2	2	2	2	2	2	2	2	2
3. Agricultural sector	142	146	139	131	135	151	151	134	127
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
5. Waste sector	20	8	65	63	110	398	387	105	117
Net CO_2 emissions	100,659	112,075	118,635	130,278	137,760	145,621	154,044	167,627	100,659
Total CO_2 emissions	124,045	133,565	142,151	153,771	161,139	168,854	176,761	190,526	200,140
GHG emission sources and absorption sinks	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy sector	190,464	209,257	213,288	220,894	232,177	241,513	248,331	255,268	259,208
1.A.1 Energy industry	105,782	121,158	126,128	130,492	139,461	145,554	152,060	58,450	163,040
1.A.2 Manufacturing and construction industries	41,305	43,955	42,716	44,802	46,393	47,864	47,324	49,089	50,374
1.A.3 Transportation	32,772	33,207	33,246	34,542	34,509	35,859	36,846	36,771	35,419
1.A.4 Other sectors	10,605	10,936	11,198	11,058	11,814	12,235	12,102	10,958	10,375
1.A.4.a Service industry	3,155	3,220	3,562	3,493	3,961	4,125	4,240	4,279	4,237
1.A.4.b Housing	5,410	5,354	5,181	5,107	5,042	5,133	5,235	5,033	5,047
1.A.4.c Agriculture, forestry, fishery, and animal husbandry	2,040	2,362	2,455	2,459	2,811	2,977	2,627	1,647	1,091
2. Industrial processes and product use sector	17,156	17,365	16,168	16,059	17,053	17,340	17,877	20,089	19,758
2.A Mining (non-metallic products)	10,746	10,486	9,974	10,648	10,270	10,691	11,257	11,014	10,369
2.B Chemical industry	1,075	1,143	1,232	1,313	1,384	1,485	1,552	1,530	1,654
2.C Metal industry	5,333	5,734	4,960	4,096	5,397	5,162	5,066	7,544	7,733
2.H Other	2	2	2	2	2	2	2	2	2
3. Agricultural sector	119	131	94	93	83	84	62	60	58
4. Land use, land use change and forestry sector	-22,550	-22,476	-21,583	-22,415	-22,305	-22,196	-21,918	-21,861	-21,650
5. Waste sector	65	259	540	612	417	512	348	470	562
Net CO2 emissions	177,441	185,254	204,535	208,506	215,243	227,425	237,253	244,701	254,025
Total CO2 emissions	207,804	227,011	230,089	237,658	249,730	259,449	266,619	275,886	279,586

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

GHG emission sources and absorption sinks	2008	2009	2010	2011	2012	2013	2014	2015	2016
1. Energy sector	247,481	235,727	251,863	257,129	252,990	253,086	258,702	258,542	262,660
1.A.1 Energy industry	157,980	148,721	158,795	163,451	161,481	160,886	169,049	168,912	172,327
1.A.2 Manufacturing and construction industries	45,485	43,000	48,239	48,760	47,655	48,415	45,276	44,345	44,186
1.A.3 Transportation	33,394	33,711	34,824	35,293	34,503	34,472	34,951	35,759	36,809
1.A.4 Other sectors	10,624	10,295	10,005	9,625	9,352	9,312	9,427	9,525	9,338
1.A.4.a Service industry	4,242	4,267	4,207	3,901	3,640	3,817	3,934	3,952	3,727
1.A.4.b Housing	5,017	5,030	4,857	4,786	4,672	4,484	4,411	4,469	4,537
1.A.4.c Agriculture, forestry, fishery, and animal husbandry	1,365	998	941	937	1,041	1,011	1,082	1,105	1,074
2. Industrial processes and product use sector	18,396	16,300	18,008	18,835	19,139	19,334	17,346	16,952	16,392
2.A Mining (non-metallic products)	9,289	8,467	8,616	9,577	9,333	9,866	8,728	8,345	7,108
2.B Chemical industry	1,457	1,514	1,599	1,637	1,503	1,572	1,603	1,605	1,612
2.C Metal industry	7,648	6,317	7,792	7,620	8,301	7,894	7,013	7,000	7,670
2.H Other	2	2	2	2	2	2	2	2	2
3. Agricultural sector	57	56	54	53	55	45	40	38	34
4. Land use, land use change and forestry sector	-21,631	-18,911	-21,413	-21,470	-21,484	-21,498	-21,410	-21,425	-21,418
5. Waste sector	443	154	208	149	149	153	146	103	131
Net CO_2 emissions	244,746	233,326	248,721	254,696	250,848	251,120	254,825	254,209	257,798
Total CO_2 emissions	266,377	252,237	270,134	276,166	272,332	272,618	276,235	275,634	279,216

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

2. Methane (CH_4)

Taiwan's principal sources of methane (CH_4) emissions were from the waste sector and the agricultural sector. Table 2.2.3 lists methane emissions from various sectors in Taiwan from 1990 to 2016, with the emission trends exhibited in Figure 2.2.4. Taiwan's methane emissions in 1990 were 11,158 kt of CO_2eq, 10,102 in 2005, and 5,637 in 2016. In 2016, the waste sector accounted for 63.30%, followed by the agriculture sector for 22.77%, the energy sector for 13.22%, and the industrial process and product use sector for 0.71%. In 2016, it was 44.19% lower than that in 2005, among which the waste sector was 55.64% lower and the agricultural sector 7.46% lower, mainly due to the change of waste disposal policy, which caused a significant decrease in landfill volume. From 2005 to 2016, methane emissions from landfills decreased by 81.80%. Moreover, domestic sewage treatment and discharge increased year by year with a rise in the percentage of houses connected to sewers, which also reduced methane emissions by 34.42% from 2005 to 2016. Additionally, methane emissions from the agricultural sector decrease year by year due to crop conversion policies and the decline of agricultural activities.

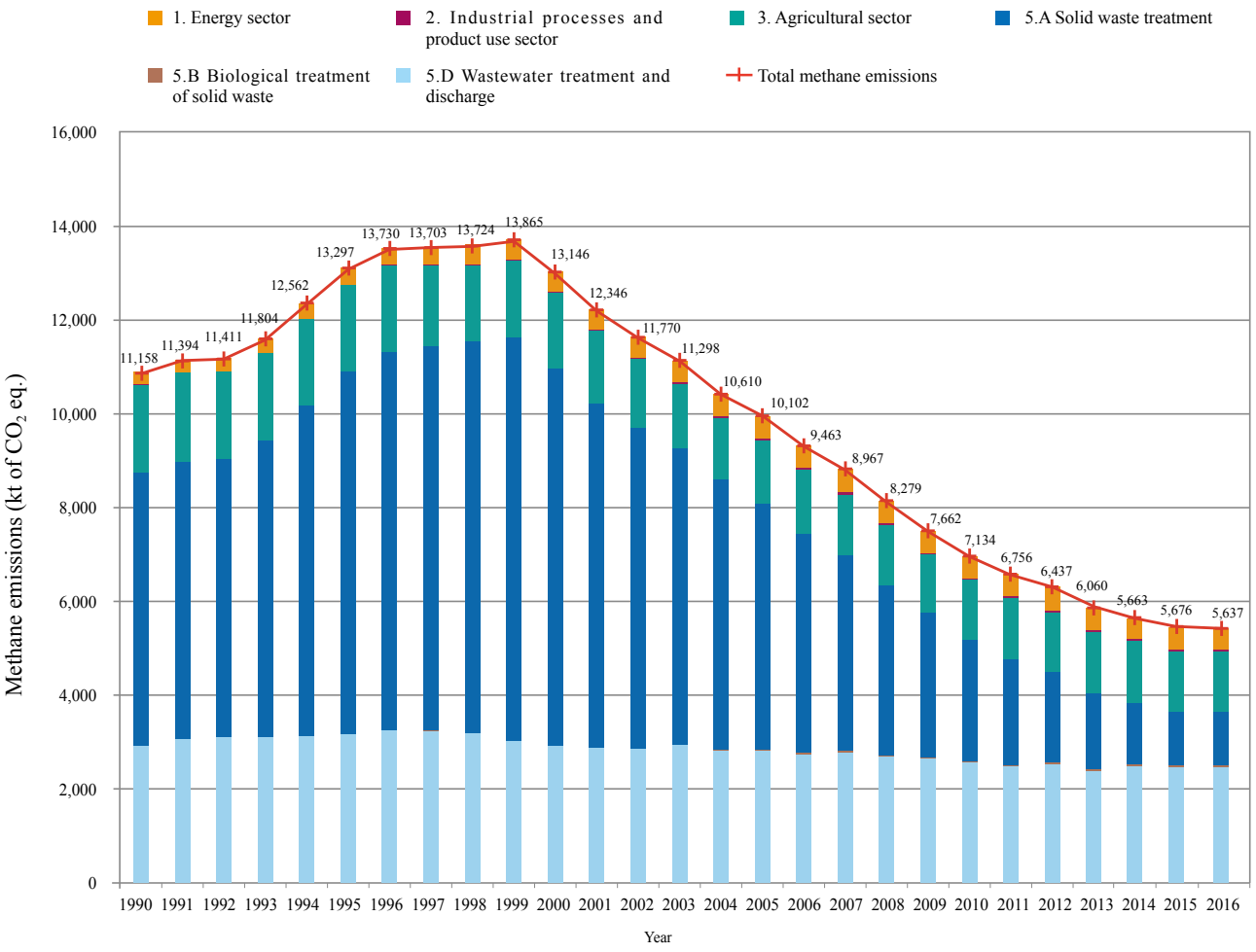


Figure 2.2.4 Trends in methane emissions in Taiwan from 2001 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.2.3 Methane emissions in Taiwan from 1990 to 2016

(Unit: kt of CO_2 eq.)

GHG emission sources and absorption sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998
1. Energy sector	530	506	497	511	526	533	550	514	535
2. Industrial processes and product use sector	5	7	6	7	8	10	11	12	10
3. Agricultural sector	1,873	1,901	1,864	1,863	1,832	1,855	1,839	1,723	1,622
3.A Gastrointestinal fermentation of livestock and poultry	670	731	738	775	789	822	822	732	674
3.B Livestock and poultry excrement and urine treatment	206	236	234	240	247	259	266	219	192
3.C Rice planting	960	908	845	825	775	767	745	765	751
3.F Burning of crop residues	38	25	48	22	21	7	7	7	6
5. Waste sector	8,750	8,980	9,044	9,423	10,196	10,899	11,329	11,454	11,556
5.A Solid waste treatment	5,832	5,917	5,928	6,323	7,061	7,719	8,080	8,212	8,372
5.B Biological treatment of solid waste	11	1	1	0	0	1	0	1	0
5.D Wastewater treatment and discharge	2,907	3,062	3,115	3,100	3,135	3,179	3,249	3,241	3,184
Total	11,158	11,394	11,411	11,804	12,562	13,297	13,730	13,703	13,724
GHG emission sources and absorption sinks	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy sector	561	574	567	586	640	674	643	637	639
2. Industrial processes and product use sector	12	14	18	19	22	28	29	33	39
3. Agricultural sector	1,644	1,618	1,565	1,479	1,394	1,320	1,387	1,368	1,341
3.A Gastrointestinal fermentation of livestock and poultry	694	692	660	636	626	614	623	614	609
3.B Livestock and poultry excrement and urine treatment	205	210	201	194	192	193	195	195	185
3.C Rice planting	738	702	689	637	567	505	561	551	543
3.F Burning of crop residues	7	14	15	13	9	8	8	8	5
5. Waste sector	11,648	10,941	10,196	9,686	9,242	8,588	8,043	7,425	6,948
5.A Solid waste treatment	8,604	8,024	7,305	6,821	6,310	5,763	5,219	4,656	4,135
5.B Biological treatment of solid waste	2	0	0	0	2	7	10	11	14
5.D Wastewater treatment and discharge	3,042	2,916	2,891	2,864	2,930	2,818	2,815	2,757	2,798
Total	13,865	13,146	12,346	11,770	11,298	10,610	10,102	9,463	8,967
GHG emission sources and absorption sinks	2008	2009	2010	2011	2012	2013	2014	2015	2016
1. Energy sector	620	612	648	670	679	691	702	725	745
2. Industrial processes and product use sector	37	33	35	27	35	38	37	39	40
3. Agricultural sector	1,299	1,281	1,274	1,301	1,300	1,304	1,286	1,268	1,283
3.A Gastrointestinal fermentation of livestock and poultry	584	571	578	590	583	579	566	573	561
3.B Livestock and poultry excrement and urine treatment	180	175	176	180	172	166	164	163	164
3.C Rice planting	529	530	514	526	540	555	552	529	555
3.F Burning of crop residues	6	5	5	5	5	3	4	4	3
5. Waste sector	6,322	5,735	5,177	4,758	4,423	4,027	3,854	3,643	3,568
5.A Solid waste treatment	3,601	3,066	2,597	2,222	1,887	1,595	1,349	1,140	950
5.B Biological treatment of solid waste	16	18	21	26	24	23	20	20	20
5.D Wastewater treatment and discharge	2,705	2,651	2,559	2,510	2,512	2,410	2,484	2,484	2,599
Total	8,279	7,662	7,134	6,756	6,437	6,060	5,878	5,676	5,637

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

3. Nitrous oxide (N_2O)

Taiwan's principal sources of nitrous oxide emissions included a small number of emissions from the agricultural sector, the industrial processes and product use sector, and the energy sector and the waste sector. Nitrous oxide emissions from agricultural sectors are essentially from agricultural soils, generated from the use of agricultural chemical fertilizers, animal excreta, nitrogen-fixing crops, crop residues, among others. In recent years, the emission of nitrous oxide from the industrial processes and product use sector has increased year by year, particularly from chemical and electronic industries. The sources of emission include caprolactam, glyoxal, glyoxylic acid, nitric acid, integrated circuits or semiconductors and TFT flat-panel displays.

Taiwan's nitrous oxide emissions in 1990 were 2,895 kt of CO_2eq, 4,181 in 2005, and about 4,701 in 2016. In 2016, the industrial processes and product use sector emitted about 1,703 kt of CO_2eq (36.29%), about 1,395 (29.67%) for the agricultural sector, about 1,270 (27.02%) for the energy sector, and about 330 (7.01%) for the waste sector, as shown in Table 2.4. From 1990 to 2016, the trend of nitrous oxide emissions in Taiwan's various sectors is demonstrated in Figure 2.2.5. From 2005 to 2016, nitrous oxide emissions increased by 12.45%, due to an increase of 77.65% in the industrial processes and product use sector. However, the agricultural sector and the waste sector dropped 12.71% and 5.57% respectively, which was mainly attributed to the reduction of agricultural soil nitrous oxide emissions by 13.55%, while the average growth rate remained -1.32%, primarily because of the change of agricultural industry structure, the reduction of the arable land area, and the promotion of rational fertilization by the COA of the Executive Yuan.

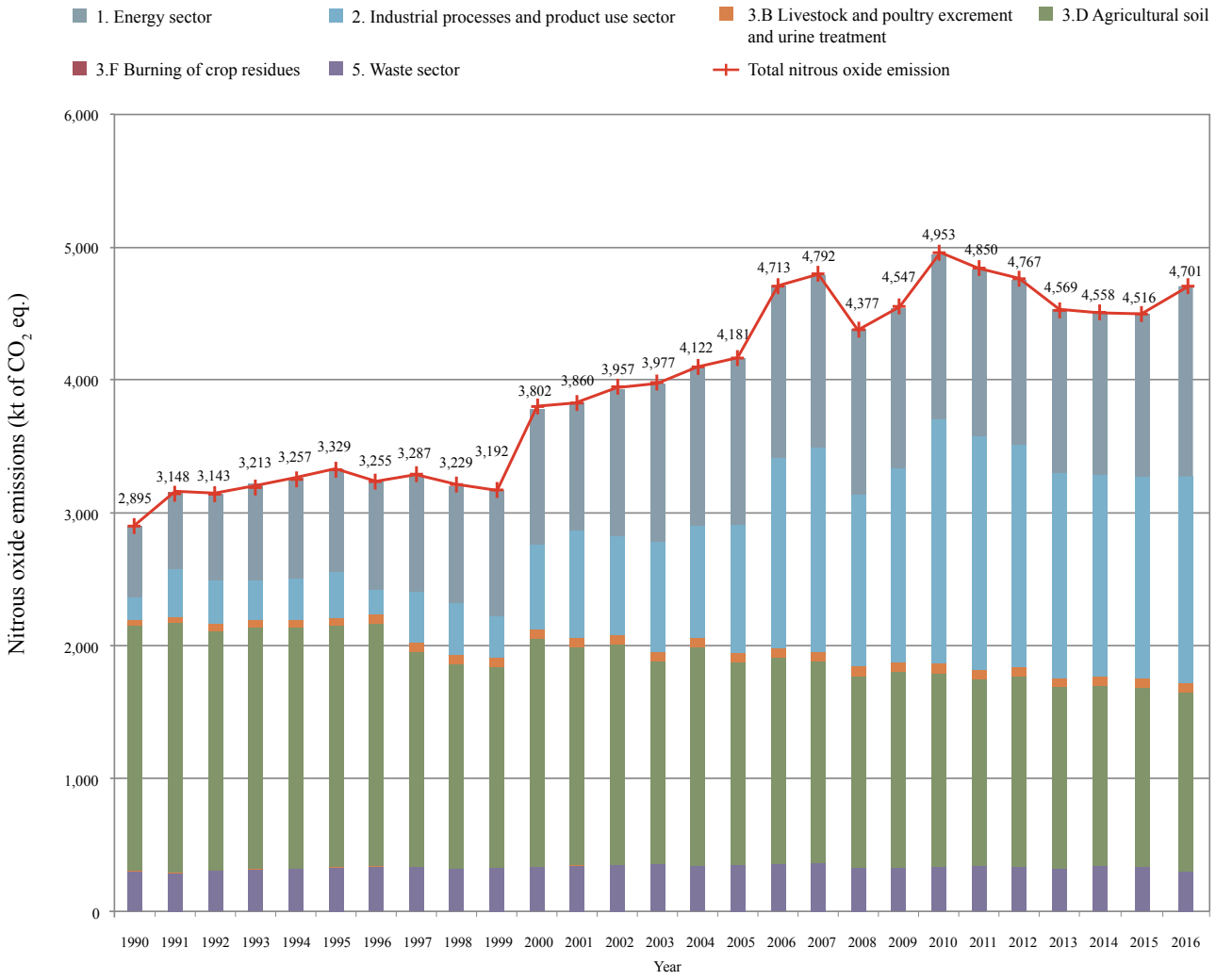


Figure 2.2.5 Trends in nitrous oxide emissions in Taiwan from 1990 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.2.4 Nitrous oxide emissions in Taiwan from 1990 to 2016

(Unit: kt of CO_2 eq.)

GHG emission sources and absorption sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998
1. Energy sector	537	578	653	703	742	778	825	866	917
1.A.1 Energy industry	138	158	183	207	224	242	273	301	332
1.A.2 Manufacturing and construction industries	90	95	101	100	102	104	107	113	115
1.A.3 Transportation	291	309	353	382	402	418	428	438	456
1.A.4 Other sectors	17	17	15	14	15	14	16	14	14
2. Industrial processes and product use sector	166	352	325	301	318	345	186	374	383
3. Agricultural sector	1,897	1,933	1,866	1,897	1,883	1,872	1,907	1,710	1,609
3.B Livestock and poultry excrement and urine treatment	48	50	52	54	59	61	67	70	71
3.D Agricultural soil	1,837	1,876	1,800	1,837	1,818	1,808	1,838	1,638	1,536
3.F Burning of crop residues	12	8	15	7	7	2	2	2	2
5. Waste sector	296	285	298	311	313	334	337	337	321
Total	2,895	3,148	3,143	3,213	3,257	3,329	3,255	3,287	3,229
GHG emission sources and absorption sinks	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy sector	968	1,052	1,086	1,136	1,194	1,234	1,273	1,302	1,306
1.A.1 Energy industry	362	428	459	482	525	538	565	590	606
1.A.2 Manufacturing and construction industries	122	133	137	143	157	165	164	171	178
1.A.3 Transportation	469	475	475	496	495	513	527	527	508
1.A.4 Other sectors	14	15	16	16	17	18	17	15	13
2. Industrial processes and product use sector	312	625	714	744	833	834	960	1,432	1,531
3. Agricultural sector	1,583	1,794	1,720	1,729	1,597	1,710	1,598	1,629	1,595
3.B Livestock and poultry excrement and urine treatment	72	73	71	70	71	69	71	72	71
3.D Agricultural soil	1,509	1,717	1,644	1,655	1,524	1,639	1,524	1,554	1,522
3.F Burning of crop residues	2	4	5	4	3	2	2	3	1
5. Waste sector	329	331	340	348	353	343	350	351	360
Total	3,192	3,802	3,860	3,957	3,977	4,122	4,181	4,713	4,792
GHG emission sources and absorption sinks	2008	2009	2010	2011	2012	2013	2014	2015	2016
1. Energy sector	1,245	1,216	1,254	1,274	1,253	1,246	1,253	1,250	1,270
1.A.1 Energy industry	588	565	573	578	573	564	571	557	567
1.A.2 Manufacturing and construction industries	162	155	169	176	170	172	166	164	162
1.A.3 Transportation	481	483	500	507	498	498	505	517	530
1.A.4 Other sectors	14	13	12	12	12	12	12	12	11
2. Industrial processes and product use sector	1,290	1,457	1,834	1,762	1,674	1,539	1,514	1,507	1,706
3. Agricultural sector	1,514	1,547	1,528	1,469	1,496	1,432	1,427	1,397	1,395
3.B Livestock and poultry excrement and urine treatment	72	71	70	71	71	71	73	74	76
3.D Agricultural soil	1,440	1,474	1,456	1,396	1,424	1,359	1,353	1,321	1,318
3.F Burning of crop residues	2	2	2	2	2	1	1	1	1
5. Waste sector	328	327	337	346	344	352	364	363	330
Total	4,377	4,547	4,953	4,850	4,767	4,569	4,558	4,516	4,701

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

4. Hydrofluorocarbons (HFCs)

Taiwan's main sources of hydrofluorocarbons (HFCs) emissions were from the industrial processes and product use sector, including fluorochemicals produced in the chemical industry as the main source in the early days, and refrigeration and air conditioning, semiconductors and fire extinguishers later. HFCs emissions in 2016 were 991 kt of CO_2eq, accounting for 0.34% of the total GHG emissions, a drop of 7.34% on 2005, with an average growth rate of -0.69%, while an increase of 0.89% compared with 2015, as shown in Figure 2.2.6 and Table 2.2.5. The only hydrochlorofluorocarbons (HFCFs) manufacturer in Taiwan, Taiwan Plastic Industry Co., Ltd. Renwu branch shut down in 2004, resulting in a decline in HFCs emissions from 2,451 kt of CO_2eq in 2004 to 1,070 in 2005. In 2011, in line with the Montreal Protocol control schedule, Taiwan's refrigeration and air-conditioning were replaced by other alternatives, and hence HFC-32, HFC-410A and HFC-404A were used in large quantities, resulting in a slight increase in emissions. However, mixed refrigerants have not yet been included in the statistical category.

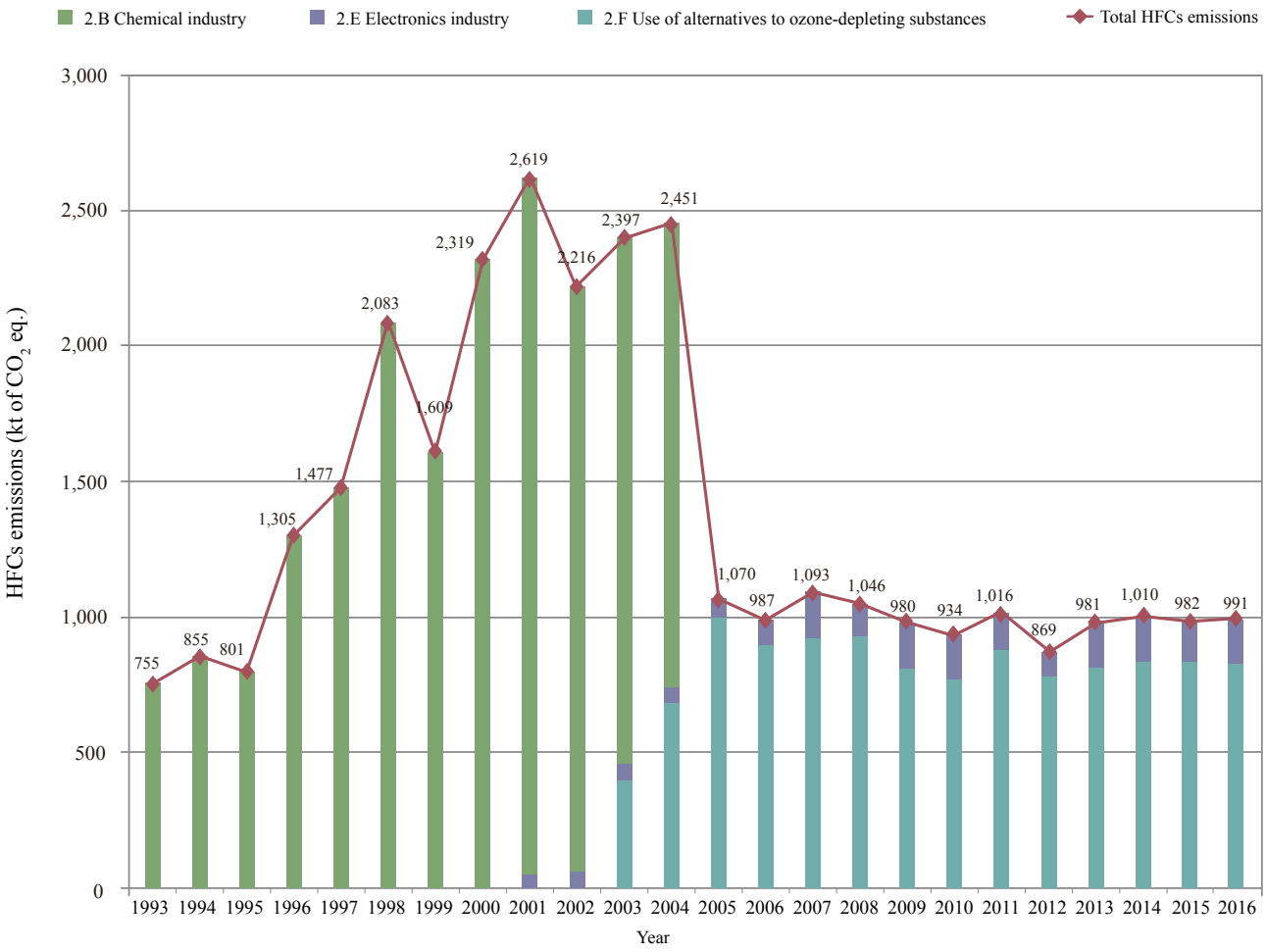


Figure 2.2.6 Trends in HFCs emissions in Taiwan from 1993 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.2.5 Hydrofluorocarbons emissions in Taiwan from 1990 to 2016

(Unit: kt of CO_2 eq.)

Sources of GHG emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998
2.B Chemical industry	NO	NO	NO	755	855	801	1,305	1,477	2,083
2.E Electronics industry	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.F Use of alternatives to ozone-depleting substances	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total	NE	NE	NE	755	855	801	1,305	1,477	2,083
Sources of GHG emissions	1999	2000	2001	2002	2003	2004	2005	2006	2007
2.B Chemical industry	1,609	2,319	2,567	2,157	1,937	1,937	NO	NO	NO
2.E Electronics industry	NE	NE	51	59	59	59	73	91	171
2.F Use of alternatives to ozone-depleting substances	NE	NE	NE	NE	401	682	996	896	922
Total	1,609	2,319	2,619	2,216	2,397	2,451	1,070	987	1,093
Sources of GHG emissions	2008	2009	2010	2011	2012	2013	2014	2015	2016
2.B Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.E Electronics industry	118	168	164	134	86	169	182	132	156
2.F Use of alternatives to ozone-depleting substances	928	812	770	881	783	812	828	851	835
Total	1,046	980	934	1,016	869	981	1,010	982	991

Note: NO (not occurring) means that there is no production or use of this classification item in Taiwan, i.e. the only HFCFs plant in Taiwan operated only from 1993 to 2004. NE (not estimated) refers to the absence of estimates of existing source emissions and sink absorption.

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

5. Perflourocarbons (PFCs)

Taiwan's main sources of PFCs emissions are from integrated circuits or semiconductors in the industrial processes and product use sector. In 2016, Taiwan's PFCs emissions were 1,045 kt of CO_2eq, representing 0.36% of total GHG emissions, which represented a drop of 65.96% in 2005, with an average growth rate of -9.33%, but experienced a slight increase of 12.27% compared with 2015, as shown in Figure 2.2.7 and Table 2.2.6. Before integrated circuits or semiconductors had been mass-produced in the early days, and relevant data on PFCs emissions were incomplete, it is impossible to estimate their emissions. Since 2004, voluntary reductions have been promoted by the Taiwan Semiconductor Industrial Association (TSIA) and the government, including the introduction and installation of tail gas treatment facilities in semiconductor and optoelectronic industries, while improving the process by means of measurement procedures, resulting in the annual decrease of PFCs emissions.

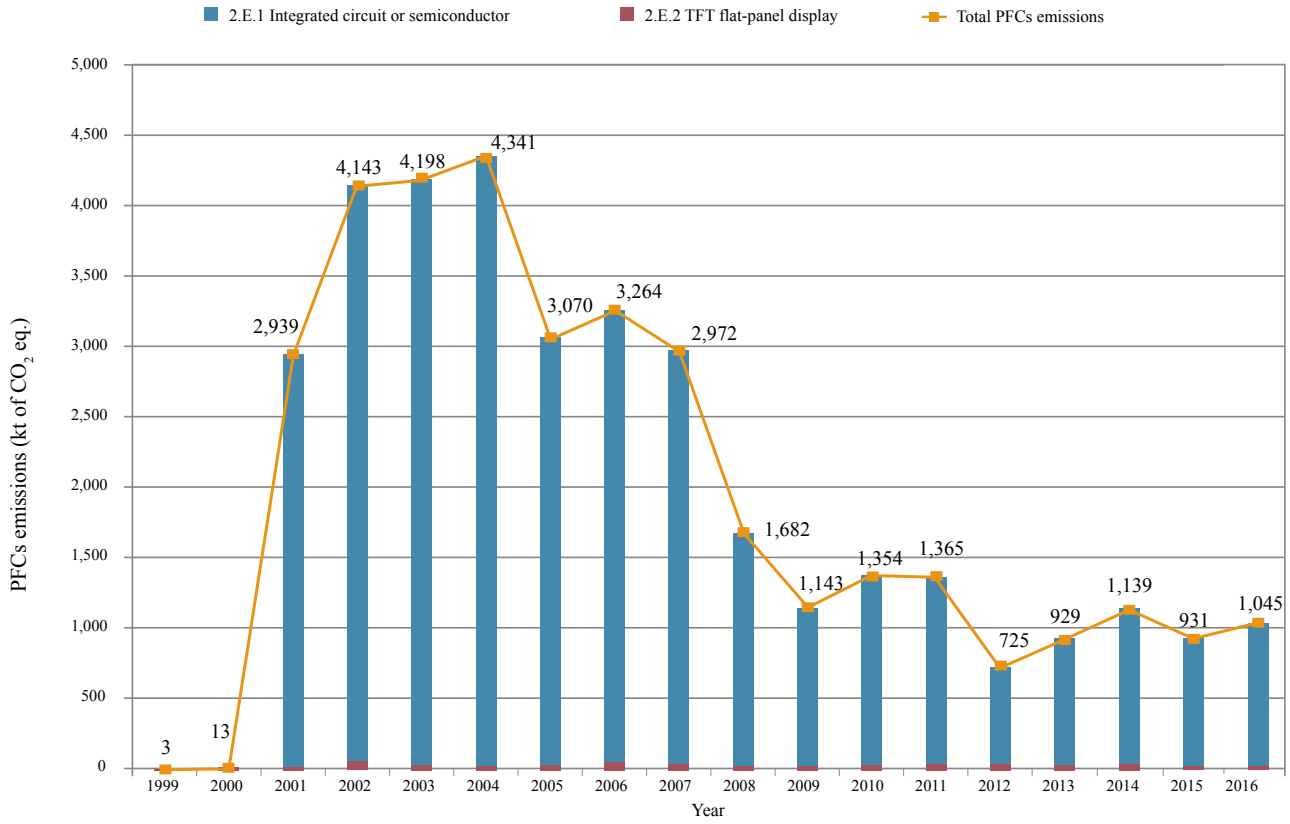


Figure 2.2.7 Trends in PFCs emissions in Taiwan from 1999 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.2.6 PFCs emissions in Taiwan from 1999 to 2016

(Unit: kt CO_2eq.)

Sources of GHG emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998
2.E.1 Integrated circuit or semiconductor	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E.2 TFT flat-panel display	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total	NE	NE	NE	NE	NE	NE	NE	NE	NE
Sources of GHG emissions	1999	2000	2001	2002	2003	2004	2005	2006	2007
2.E.1 Integrated circuit or semiconductor	3	13	2,933	4,077	4,173	4,327	3,043	3,211	2,933
2.E.2 TFT flat-panel display	NE	NE	6	65	25	14	27	53	39
Total	3	13	2,939	4,143	4,198	4,341	3,070	3,264	2,972
Sources of GHG emissions	2008	2009	2010	2011	2012	2013	2014	2015	2016
2.E.1 Integrated circuit or semiconductor	1,657	1,126	1,322	1,335	691	899	1,114	917	1,030
2.E.2 TFT flat-panel display	25	17	32	30	33	30	26	14	16
Total	1,682	1,143	1,354	1,365	725	929	1,139	931	1,045

Note: NE (not estimated) refers to the absence of estimates of existing source emissions and sink absorption.

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

6. Sulfur hexafluoride (SF_6)

Taiwan's main sources of SF_6 emissions came from the electronics industry and power equipment of the industrial processes and product use sector. In 2016, Taiwan's SF_6 emissions accounted for 1,094 kt of CO_2eq, making up 0.37% of total GHG emissions. In comparison with 2005, representing a 76.64% reduction, with an average growth rate of -12.383%, and a 10.11% lower compared with 2015, as exhibited in Figure 2.2.8 and Table 2.2.7. SF_6 emissions have been on the rise year after year since 2002, due to the increase in the production and use of TFT flat-panel displays, power equipment and magnesium, with a reaching an emission peak of 5,193 kt of CO_2eq in 2004, and subsequently, experienced a decrease in the use of SF_6. The emission of SF_6 in the electronics industry fell by 52.03% in 2016 compared with 2005, with an average growth rate of -6.46%.

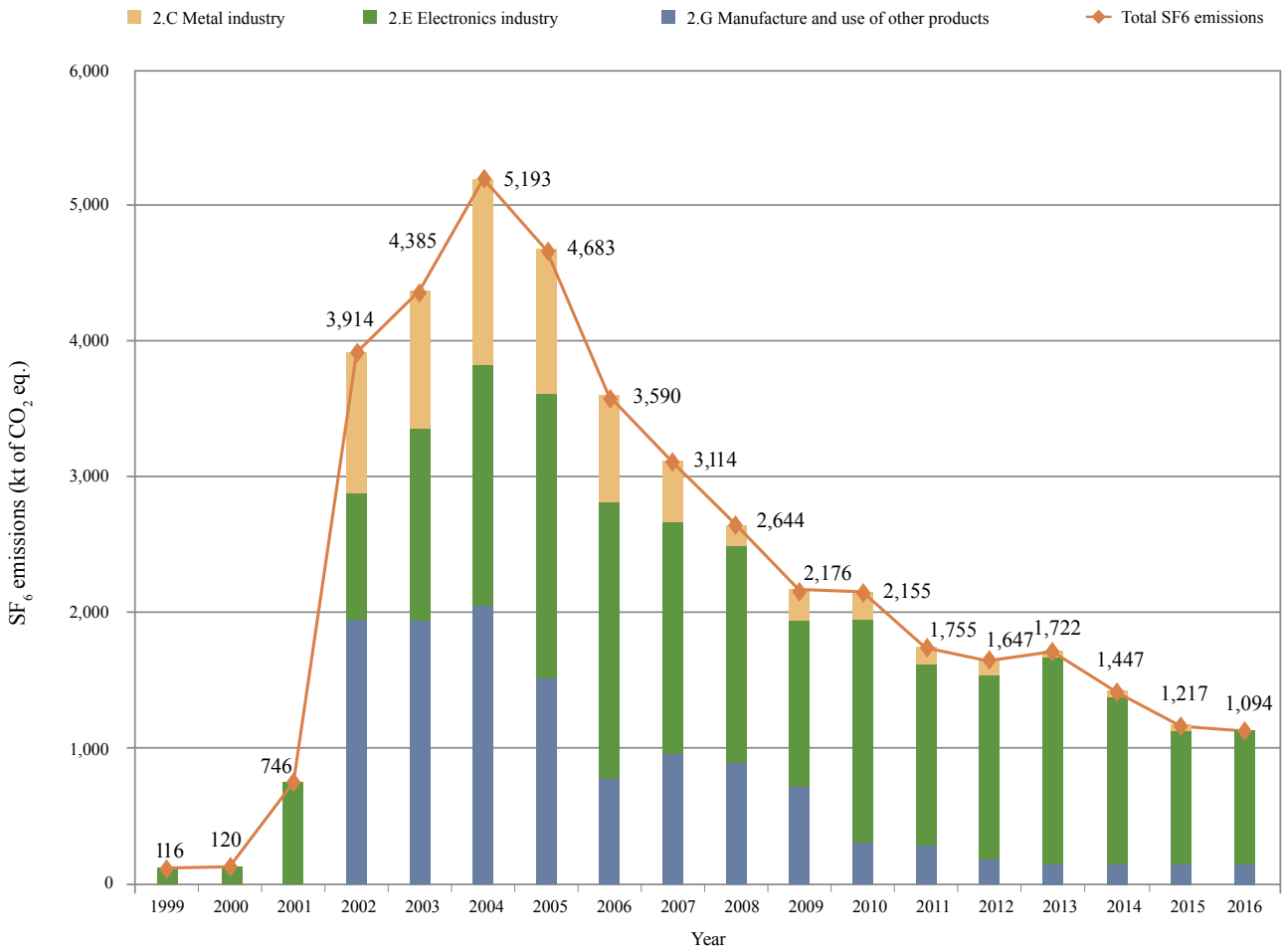


Figure 2.2.8 Trends in SF_6 emissions in Taiwan from 1999 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.2.7 SF_6 emissions in Taiwan from 1990 to 2016

(Unit: kt CO_2eq)

Sources of GHG emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998
2.C Metal industry	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E Electronics industry	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G Manufacture and use of other products	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total	NE	NE	NE	NE	NE	NE	NE	NE	NE
Sources of GHG emissions	1999	2000	2001	2002	2003	2004	2005	2006	2007
2.C Metal industry	NE	NE	NE	1,027	2,003	1,357	1,063	770	440
2.E Electronics industry	116	120	746	944	1,027	1,783	2,117	2,050	1,721
2.G Manufacture and use of other products	NE	NE	NE	1,943	1,415	2,053	1,503	770	953
Total	116	120	746	3,914	4,385	5,193	4,683	3,590	3,114
Sources of GHG emissions	2008	2009	2010	2011	2012	2013	2014	2015	2016
2.C Metal industry	144	235	212	134	109	55	56	45	NE
2.E Electronics industry	1,605	1,239	1,648	1,339	1,352	1,524	1,276	1,075	1,015
2.G Manufacture and use of other products	895	703	295	282	186	142	115	97	79
Total	2,644	2,176	2,155	1,755	1,647	1,722	1,447	1,217	1,094

Note: NE (not estimated) means the absence of estimates of existing source emissions and sink removals.

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

7. Nitrogen trifluoride (NF_3)

ThThe main sources of NF_3 emissions in Taiwan were semiconductors from industrial processes and product use sectors. In 2016, Taiwan's NF_3 emissions were 440 kt of CO_2eq, constituting 0.15% of total GHG emissions, 39.45% lower than in 2005, with an average growth rate of -4.46%, and 29.40% lower compared with 2015, as demonstrated in Figure 2.2.9 and Table 2.2.8. NF_3 emissions have been rising year by year since 2001, as a result of the increased use of semiconductors, and they have been reduced from 759 kt of CO_2eq in 2007 to 166 in 2008, due to a sharp decrease in semiconductor use. After 2012, when the use of semiconductors and TFT flat-panel displays increased, NF_3 emissions rose from 349 kt of CO_2eq in 2012 to 440 in 2016.

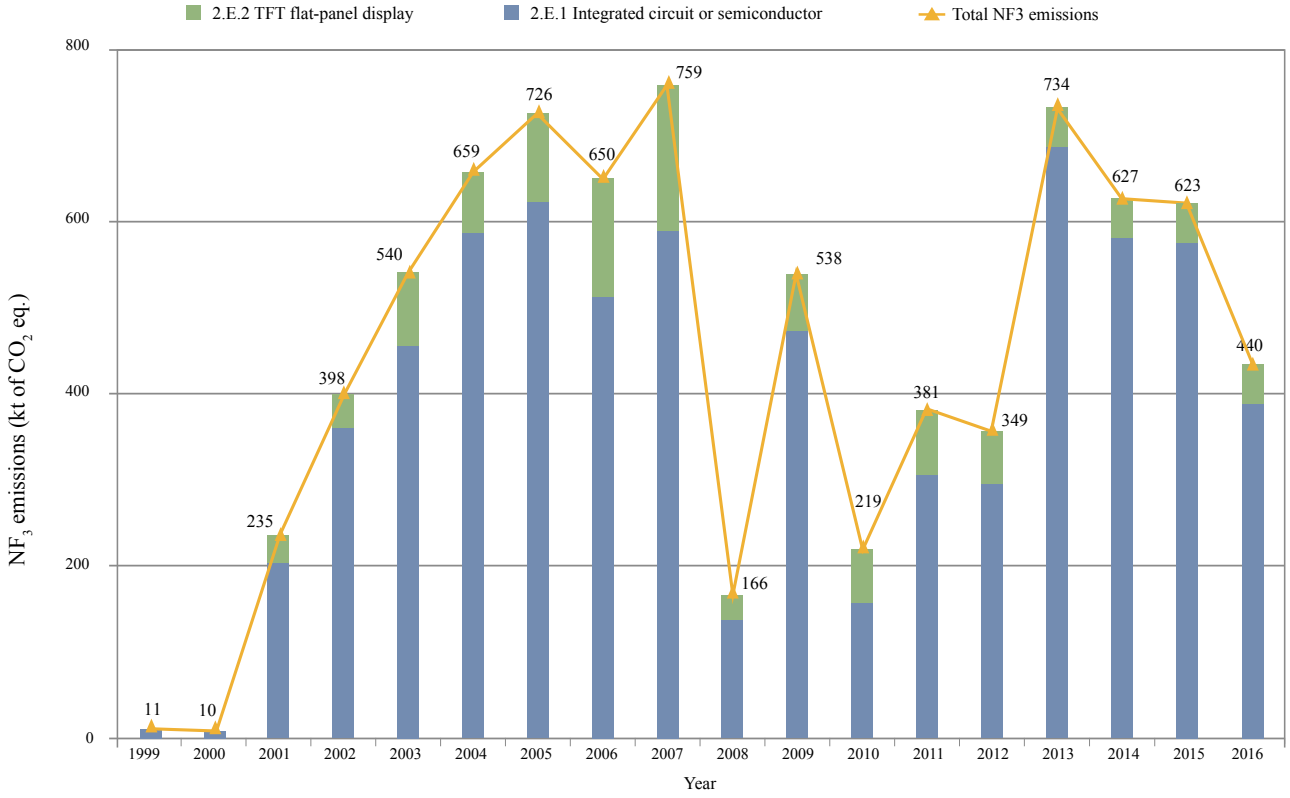


Figure 2.2.9 Trends in NF_3 emissions in Taiwan from 1999 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.2.8 NF_3 emissions in Taiwan from 1990 to 2016

(Unit: kt CO_2eq.)

Sources of GHG emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998
2.E.1 Integrated circuit or semiconductor	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E.2 TFT flat-panel display	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total	NE	NE	NE	NE	NE	NE	NE	NE	NE
Sources of GHG emissions	1999	2000	2001	2002	2003	2004	2005	2006	2007
2.E.1 Integrated circuit or semiconductor	11	10	202	359	455	587	623	512	590
2.E.2 TFT flat-panel display	NE	NE	33	39	86	72	103	138	170
Total	11	10	235	398	540	659	726	650	759
Sources of GHG emissions	2008	2009	2010	2011	2012	2013	2014	2015	2016
2.E.1 Integrated circuit or semiconductor	136	473	156	306	295	687	531	562	387
2.E.2 TFT flat-panel display	30	65	62	75	54	46	96	61	52
Total	166	538	219	381	349	734	627	623	440

Note: NE (not estimated) means the absence of estimates of existing source emissions and sink absorption.

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

2.3 Statistics of GHG emissions and absorptions by sector

In terms of sectors, the energy sector's GHG emissions in 2016 were 264,675 kt of CO_2eq (excluding land-use change and forestry removals), accounting for 90.29% of Taiwan's total GHG emissions, 21,708 for the industrial processes and product use sector (7.41%), 2,712 for the agricultural sector (0.93%), and 4,029 for the waste sector (1.37%). Moreover, in 2016, the removal of 21,418 kt of CO_2eq from the land use, land-use change and forestry sector constituted 7.31% of total emissions. The trend in GHG emissions by sector in Taiwan from 1990 to 2016 is shown in Figure 2.3.1 and Table 2.3.1

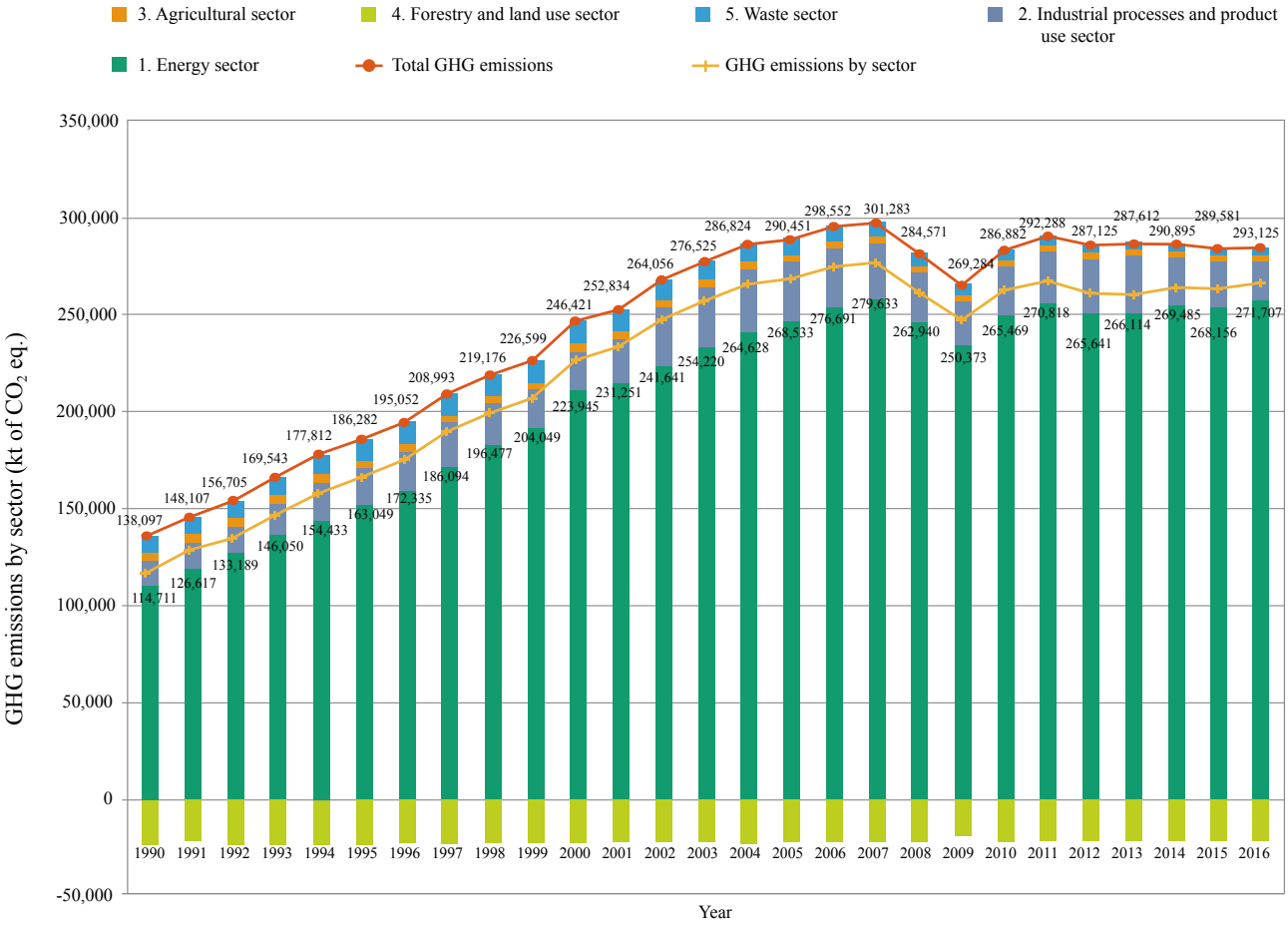


Figure 2.3.1 Trends in GHG emissions by sector in Taiwan from 1990 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.3.1 Trends in GHG emissions by sector in Taiwan from 1990 to 2016

(Unit: kt CO_2eq.)

GHG emission sources and absorption sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998
1. Energy sector	110,525	119,521	127,202	136,414	144,365	152,115	159,948	172,207	182,963
2. Industrial processes and product use sector	14,595	15,333	16,227	19,441	18,977	18,658	19,154	21,323	20,862
3. Agricultural sector	3,911	3,980	3,869	3,890	3,850	3,878	3,897	3,567	3,359
4. Land use and forestry sector	-23,386	-21,490	-23,516	-23,493	-23,379	-23,233	-22,717	-22,899	-22,699
5. Waste sector	9,066	9,273	9,407	9,798	10,619	11,631	12,053	11,896	11,993
Net GHG emissions (including land use, land-use change and forestry removal)	114,711	126,617	133,189	146,050	154,433	163,049	172,335	186,094	196,477
Total GHG emissions (excluding land use, land-use change and forestry removal)	138,097	148,107	156,705	169,543	177,812	186,282	195,052	208,993	219,176
GHG emission sources and absorption sinks	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy sector	191,993	210,882	214,941	222,616	234,011	243,421	250,247	257,207	261,153
2. Industrial processes and product use sector	19,218	20,465	23,438	27,492	29,428	30,846	28,416	30,044	29,266
3. Agricultural sector	3,345	3,543	3,379	3,301	3,074	3,114	3,047	3,056	2,993
4. Land use and forestry sector	-22,550	-22,476	-21,583	-22,415	-22,305	-22,196	-21,918	-21,861	-21,650
5. Waste sector	12,042	11,530	11,076	10,646	10,012	9,444	8,741	8,245	7,871
Net GHG emissions (including land use, land-use change and forestry removal)	204,049	223,945	231,251	241,641	254,220	264,628	268,533	276,691	279,633
Total GHG emissions (excluding land use, land-use change and forestry removal)	226,599	246,421	252,834	264,056	276,525	286,824	290,451	298,552	301,283
GHG emission sources and absorption sinks	2008	2009	2010	2011	2012	2013	2014	2015	2016
1. Energy sector	249,346	237,555	253,765	259,073	254,922	255,023	260,657	260,517	264,675
2. Industrial processes and product use sector	25,261	22,628	24,539	25,141	24,437	25,275	23,121	22,252	21,708
3. Agricultural sector	2,870	2,884	2,856	2,823	2,851	2,781	2,753	2,703	2,712
4. Land use and forestry sector	-21,631	-18,911	-21,413	-21,470	-21,484	-21,498	-21,410	-21,425	-21,418
5. Waste sector	7,094	6,216	5,722	5,252	4,916	4,532	4,364	4,109	4,029
Net GHG emissions (including land use, land-use change and forestry removal)	262,940	250,372	265,469	270,818	265,641	266,114	269,485	268,156	271,706
Total GHG emissions (excluding land use, land-use change and forestry removal)	284,571	269,283	286,882	292,288	287,125	287,612	290,895	289,581	293,125

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report

The following section presents an overview of GHG emissions by sector according to the UNFCCC regulations:

1. Energy sector

The GHGs emitted by Taiwan's energy sector included carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The total GHG emissions in the sector have shown an upward trend over the years and a downward trend for the first time in 2008, declining again in 2009, 2012 and 2015, and a 1.60% rise in 2016, compared with 2015, as shown in Table 2.3.2 and Figure 2.3.2.

In 2016, the total GHG emissions from the energy sector were 264,675 kt of CO_2eq, constituting 90.29% of Taiwan's total GHG emissions; 264,436 for "fuel combustion activities," accounting for 99.91% of the total GHG emissions from the energy sector, and 239 for "fugitive emissions from fuels," representing 0.09%. Among them, 1.A.1 "Energy industry" amounted 172,984 tonnes of CO_2eq, composing 65.36% of the total GHG emissions from the energy sector, 44,438 kt of CO_2eq for 1.A.2 "Manufacturing and construction industries" (16.79%), 37,640 for 1.A.3 "Transportation" (14.22%), 9,373 for 1.A.4 "Other sectors (including service, housing, and agriculture, forestry, fishery and animal husbandry) (3.54%), and 239 for 1.B.2 "Oil and natural gas" (0.09%).

Between 2005 and 2016, the energy sector grew by 5.77%, with an average annual growth rate of 0.51%, of which 1.A.1 "Energy industry" increased 13.28% in GHG emissions, with an average annual growth rate of 1.14%; 1.A.2 "Manufacturing and construction industries" fell by 6.60%, with an average annual growth rate of -0.62%; 1.A.3 "Transportation" dropped 0.09%, with an average annual growth rate of -0.01%; 1.A.4 "Other sectors" went down 22.86%, with an annual growth rate of -2.33%; and 1.B.2 "Oil and natural gas" grew by 74.95%, with an average annual growth rate of 5.22%.

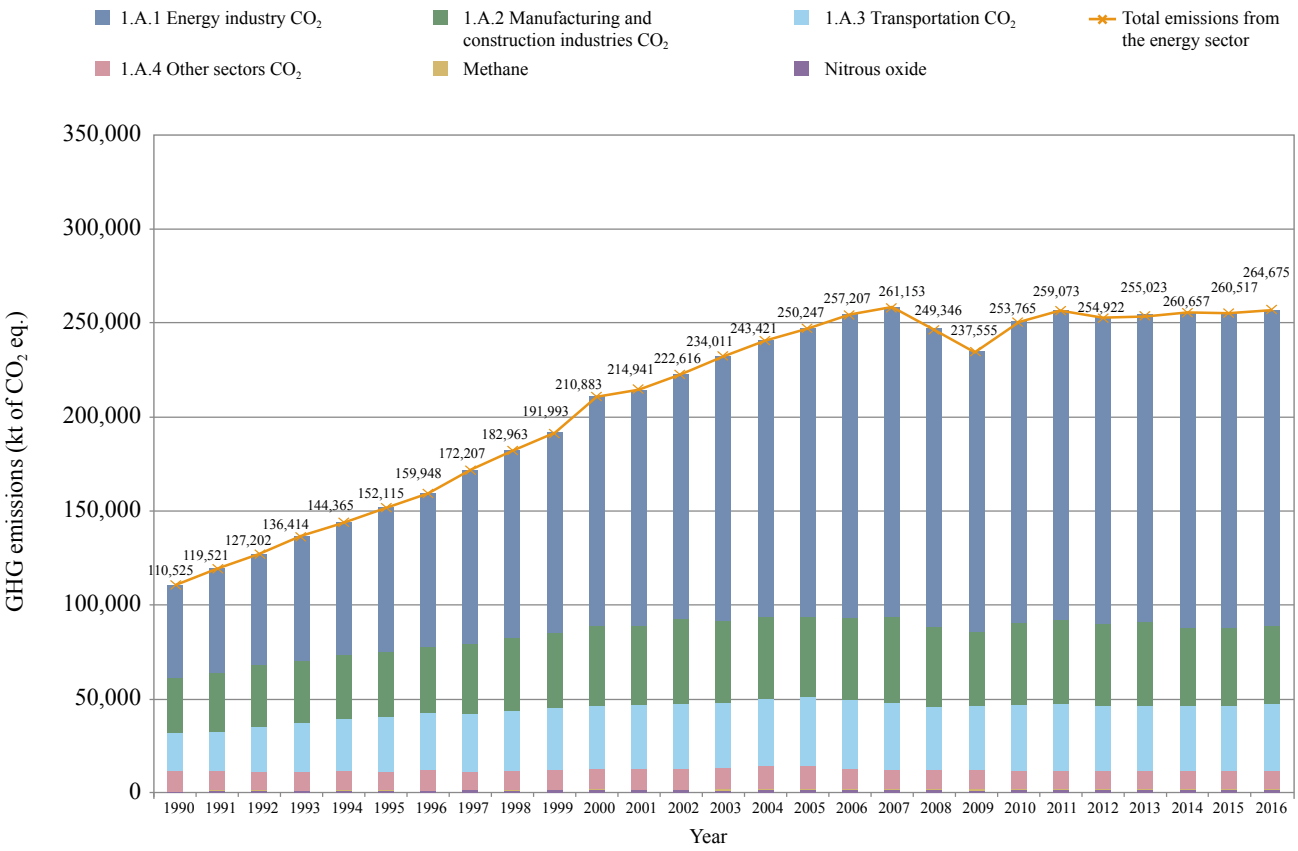


Figure 2.3.2 Trends in GHG emissions from Taiwan's energy sector from 1990 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.3.2 GHG emissions from Taiwan's energy sector from 1990 to 2016

(Unit: kt CO_2eq.)

GHG emission sources and absorption sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total CO_2 emissions	109,459	118,436	126,052	135,199	143,097	150,804	158,573	170,828	181,511
1.A.1 Energy industry	49,123	55,126	58,529	65,962	70,771	76,400	81,254	91,407	100,415
1.A.2 Manufacturing and construction industries	30,117	31,956	33,383	33,611	34,586	35,763	36,785	39,075	39,311
1.A.3 Transportation	19,646	20,888	24,033	26,103	27,540	28,822	29,801	30,536	31,844
1.A.4 Other sectors	10,572	10,466	10,107	9,523	10,200	9,820	10,733	9,809	9,940
Total CH_4 emissions	530	506	497	511	526	533	550	514	535
1.A.1 Energy industry	26	29	28	32	35	41	42	46	51
1.A.2 Manufacturing and construction industries	46	48	51	51	52	53	55	58	59
1.A.3 Transportation	152	163	187	202	216	228	239	245	257
1.A.4 Other sectors	30	29	28	26	28	27	29	26	27
1.B.1 Solid fuel	162	138	115	113	98	81	81	34	27
1.B.2 Oil and natural gas	115	98	88	87	97	103	103	104	115
Total N_2O emissions	537	578	653	703	742	778	825	866	917
1.A.1 Energy industry	138	158	183	207	224	242	273	301	332
1.A.2 Manufacturing and construction industries	90	95	101	100	102	104	107	113	115
1.A.3 Transportation	291	309	353	382	402	418	428	438	456
1.A.4 Other sectors	17	17	15	14	15	14	16	14	14
Total emissions from the energy sector	110,525	119,521	127,202	136,414	144,365	152,115	159,948	172,207	182,963
GHG emission sources and absorption sinks	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total CO_2 emissions	190,464	209,257	213,288	220,894	232,177	241,513	248,331	255,268	259,208
1.A.1 Energy industry	105,782	121,158	126,128	130,492	139,461	145,554	152,060	158,450	163,040
1.A.2 Manufacturing and construction industries	41,305	43,955	42,716	44,802	46,393	47,864	47,324	49,089	50,374
1.A.3 Transportation	32,772	33,207	33,246	34,542	34,509	35,859	36,846	36,771	35,419
1.A.4 Other sectors	10,605	10,936	11,198	11,058	11,814	12,235	12,102	10,958	10,375
Total CH_4 emissions	561	574	567	586	640	674	643	637	639
1.A.1 Energy industry	59	66	70	70	79	81	82	86	88
1.A.2 Manufacturing and construction industries	63	69	72	76	84	89	88	92	97
1.A.3 Transportation	266	270	272	278	287	295	303	298	289
1.A.4 Other sectors	28	29	30	30	32	33	33	29	27
1.B.1 Solid fuel	31	28	NO	NO	NO	NO	NO	NO	NO
1.B.2 Oil and natural gas	113	111	122	132	159	176	137	132	138
Total N_2O emissions	968	1,052	1,086	1,136	1,194	1,234	1,273	1,302	1,306
1.A.1 Energy industry	362	428	459	482	525	538	565	590	606
1.A.2 Manufacturing and construction industries	122	133	137	143	157	165	164	171	178
1.A.3 Transportation	469	475	475	496	495	513	527	527	508
1.A.4 Other sectors	14	15	16	16	17	18	17	15	13
Total emissions from the energy sector	191,993	210,883	214,941	222,616	234,011	243,421	250,247	257,207	261,153

Note: NO (not occurring), as coal production in Taiwan has been suspended since 2001.

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

GHG emission sources and absorption sinks	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total CO_2 emissions	247,481	235,727	251,863	257,129	252,990	253,086	258,702	258,542	262,660
1.A.1 Energy industry	157,980	148,721	158,795	163,451	161,481	160,886	169,049	168,912	172,327
1.A.2 Manufacturing and construction industries	45,485	43,000	48,239	48,760	47,655	48,415	45,276	44,345	44,186
1.A.3 Transportation	33,394	33,711	34,824	35,293	34,503	34,472	34,951	35,759	36,809
1.A.4 Other sectors	10,624	10,295	10,005	9,625	9,352	9,312	9,427	9,525	9,338
Total CH_4 emissions	620	612	648	670	679	691	702	725	745
1.A.1 Energy industry	86	79	84	85	84	83	86	90	90
1.A.2 Manufacturing and construction industries	88	85	92	97	94	96	93	92	91
1.A.3 Transportation	276	281	285	288	284	284	286	293	301
1.A.4 Other sectors	28	27	26	25	24	24	25	25	24
1.B.1 Solid fuel	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B.2 Oil and natural gas	142	140	161	176	193	204	212	226	239
Total N_2O emissions	1,245	1,216	1,254	1,274	1,253	1,246	1,253	1,250	1,270
1.A.1 Energy industry	588	565	573	578	573	564	571	557	567
1.A.2 Manufacturing and construction industries	162	155	169	176	170	172	166	164	162
1.A.3 Transportation	481	483	500	507	498	498	505	517	530
1.A.4 Other sectors	14	13	12	12	12	12	12	12	11
Total emissions from the energy sector	249,346	237,555	253,765	259,073	254,922	255,023	260,657	260,517	264,675

Note: NO (not occurring), as coal production in Taiwan has been suspended since 2001.

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

2. Industrial processes and product use sector

The GHGs emitted by Taiwan's industrial processes and product use sector were composed of CO_2, CH_4, N_2O, PFCs, HFCs, SF_6 and NF_3. The GHG emissions from the sector over the years are listed in Table 2.3.3 and Figure 2.3.3.

In 2016, the total GHG emissions from the industrial processes and product use sector were 21,708 kt of CO_2eq, representing about 7.41% of Taiwan's total GHG emissions. Among them, 2.C "Metal industry" accounted for 35.33% of the sector's emissions, which constituted the greatest proportion, followed by 2.A "Mining (non-metallic products)" for 32.74% and 2.E "Electronics industry" for 15.67%.

From 2005 to 2016, GHG emissions from industrial processes and product use dropped by 23.60%, with an average annual growth rate of -2.42%. In 2004, emissions of 30,846 kt of CO_2eq reached a historic high, making up about 10.75% of Taiwan's total GHG emissions. GHG emissions declined year by year after 2005. By 2010, GHG emissions from industrial processes and product use sectors were on the rise due to CO_2 emissions produced from steel production in the metal industry, SF_6 emissions from TFT flat-panel displays, and PFCs emissions from semiconductors. From 2014 onward, the use of SF_6 in cement production and TFT flat-panel displays and NF_3 in semiconductors has been cut down, leading to a reduction in emissions from industrial processes and product use. Between 2005 and 2016, GHG emissions from 2.A "Mining (non-metallic products)" decreased by 36.86%, with an average annual growth rate of -4.09%, while GHG emissions from 2.B "Chemical industry" grew by 2.82%, with an average annual growth rate of 0.25%.

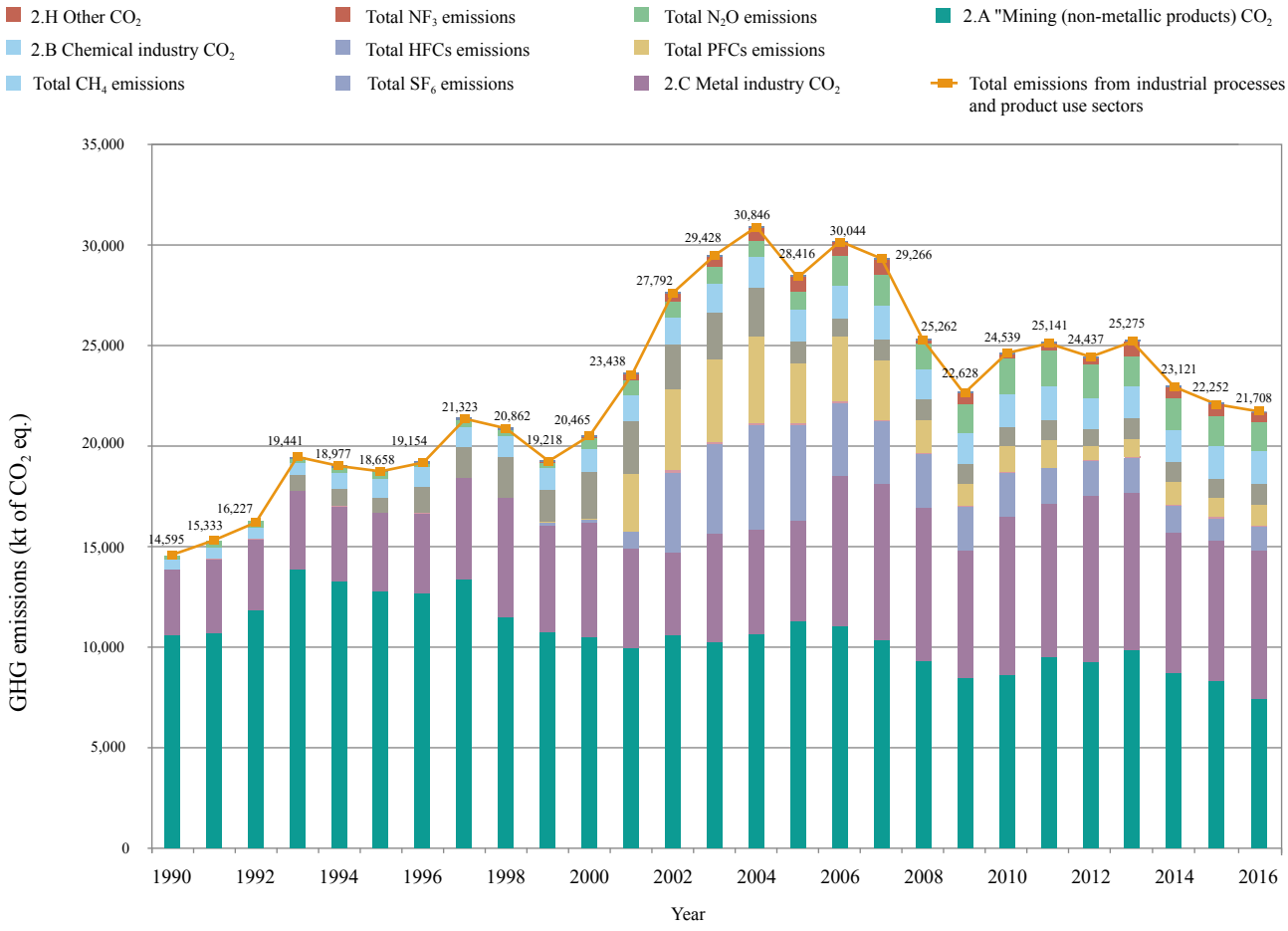


Figure 2.3.3 Trends in GHG emissions from the industrial processes and product use sector in Taiwan from 1990 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.3.3 GHG emissions from the industrial processes and product use sector in Taiwan from 1990 to 2016

(Unit: kt of CO_2eq.)

GHG emission sources and absorption sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total CO_2 emissions	14,424	14,975	15,895	18,378	17,797	17,501	17,651	19,460	18,386
2.A "Mining (non-metallic products)	10,584	10,698	11,854	13,879	13,259	12,766	12,645	13,394	11,564
2.B Chemical industry	563	539	565	609	762	850	992	1,020	1,003
2.C Metal industry	3,275	3,735	3,474	3,888	3,774	3,884	4,013	5,045	5,817
2.H Other	2	2	2	2	2	2	2	2	2
Total CH_4 emissions	5	7	6	7	8	10	11	12	10
Total N_2O emissions	66	352	325	301	318	345	186	374	383
2.B Chemical industry	166	352	325	301	318	345	186	374	383
2.C Metal industry	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E Electronics industry	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total HFCs emissions	NE	NE	NE	755	855	801	1,305	1,477	2,083
2.B Chemical industry	NE	NE	NE	755	855	801	1,305	1,477	2,083
2.E Electronics industry	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.F Use of alternatives to ozone-depleting substances	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total PFCs emissions (2.E Electronics industry)	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total SF_6 emissions	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.C Metal industry	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E Electronics industry	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total NF_3 emissions (2.E Electronics industry)	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G Manufacture and use of other products	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total emissions from industrial processes and product use sectors	14,595	15,333	16,227	19,441	18,977	18,658	19,154	21,323	20,862
GHG emission sources and absorption sinks	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total CO_2 emissions	17,156	17,365	16,168	16,059	17,053	17,340	17,877	20,089	19,758
2.A "Mining (non-metallic products)	10,746	10,486	9,974	10,648	10,270	10,691	11,257	11,014	10,369
2.B Chemical industry	1,075	1,143	1,232	1,313	1,384	1,485	1,552	1,530	1,654
2.C Metal industry	5,333	5,734	4,960	4,096	5,397	5,162	5,066	7,544	7,733
2.H Other	2	2	2	2	2	2	2	2	2
Total CH_4 emissions	12	14	18	19	22	28	29	33	39
Total N_2O emissions	312	625	714	744	833	834	960	1,432	1,531
2.B Chemical industry	312	625	714	743	831	834	960	969	996
2.C Metal industry	NE	NE	NE	0	2	NE	NE	94	95
2.E Electronics industry	NE	NE	NE	NE	NE	NE	NE	369	439
Total HFCs emissions	1,609	2,319	2,619	2,216	2,397	2,451	1,070	987	1,093
2.B Chemical industry	1,609	2,319	2,567	2,157	1,937	1,710	NE	NE	NE
2.E Electronics industry	NE	NE	51	59	59	59	73	91	171
2.F Use of alternatives to ozone-depleting substances	NE	NE	NE	NE	401	682	996	896	922
Total PFCs emissions (2.E Electronics industry)	3	13	2,939	4,143	4,198	4,341	3,070	3,264	2,972

Note: NE (not estimated) means the absence of estimates of existing source emissions and sink removals.

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

GHG emission sources and absorption sinks	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total SF_6 emissions	116	120	746	3,914	4,385	5,193	4,683	3,590	3,114
2.C Metal industry	NE	NE	NE	1,027	1,027	1,357	1,063	770	440
2.E Electronics industry	116	120	746	944	1,415	1,783	2,117	2,050	1,721
Total NF_3 emissions (2.E Electronics industry)	NE	NE	NE	1,943	1,943	2,053	1,503	770	953
2.G Manufacture and use of other products	11	10	235	398	540	659	726	650	759
Total emissions from industrial processes and product use sectors	19,218	20,465	23,438	27,492	29,428	30,846	28,416	30,044	29,266
GHG emission sources and absorption sinks	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total CO_2 emissions	18,396	16,300	18,008	18,835	19,139	19,334	17,346	16,952	16,392
2.A "Mining (non-metallic products)	9,289	8,467	8,616	9,577	9,333	9,866	8,728	8,345	7,108
2.B Chemical industry	1,457	1,514	1,599	1,637	1,503	1,572	1,603	1,605	1,612
2.C Metal industry	7,648	6,317	7,792	7,620	8,301	7,894	7,013	7,000	7,670
2.H Other	2	2	2	2	2	2	2	2	2
Total CH_4 emissions	37	33	35	27	35	38	37	39	40
Total N_2O emissions	1,290	1,457	1,834	1,762	1,674	1,539	1,514	1,507	1,706
2.B Chemical industry	784	1,006	1,170	1,195	1,016	780	728	691	961
2.C Metal industry	90	76	119	NE	NE	NE	NE	NE	NE
2.E Electronics industry	416	375	546	568	658	759	786	817	745
Total HFCs emissions	1,046	980	934	1,016	869	981	1,010	982	991
2.B Chemical industry	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E Electronics industry	118	168	164	134	86	169	182	132	156
2.F Use of alternatives to ozone-depleting substances	928	812	770	881	783	812	828	851	835
Total PFCs emissions (2.E Electronics industry)	1,682	1,143	1,354	1,365	725	929	1,139	931	1,045
Total SF_6 emissions	2,644	2,176	2,155	1,755	1,647	1,722	1,447	1,217	1,094
2.C Metal industry	144	235	212	134	109	55	56	45	NE
2.E Electronics industry	1,605	1,239	1,648	1,339	1,352	1,524	1,276	1,075	1,015
Total NF_3 emissions (2.E Electronics industry)	895	703	295	282	186	142	115	97	79
2.G Manufacture and use of other products	166	538	219	381	349	734	627	623	440
Total emissions from industrial processes and product use sectors	25,262	22,628	24,539	25,141	24,437	25,275	23,121	22,252	21,708

Note: NE (not estimated) means the absence of estimates of existing source emissions and sink removals.

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

3. Agricultural sector

The GHGs released by Taiwan's agricultural sector included CH_4, N_2O and a small amount of CO_2. The GHG emissions from the sector presented a downward trend year by year. In 2016, emissions of 2,712 kt of CO_2eq accounted approximately for 0.93% of Taiwan's total GHG emissions. Among them, N_2O emissions from 3.F "Agricultural soil" represented 48.59% of the GHG emissions in the agricultural sector, which constituted the greatest proportion, followed by CH_4 emissions (20.69%) from 3.A "Gastrointestinal fermentation of livestock and poultry" and CH_4 emissions (20.47%) from 3.C "Rice Planting." Emissions from the agricultural sector over the years are shown in Figure 2.3.4 and Table 2.3.4. Taiwan's agricultural sector GHG emissions rose by 0.35% in 2016, compared with 2015. Among them, in 2016, N_2O emissions from 3.D "Agricultural soil" accounted for 48.59%; CH_4 emissions from 3.A "Gastrointestinal fermentation of livestock and poultry" for 20.69%; CH_4 emissions from 3.C "Rice planting" for 20.47%, CH_4 emissions from 3.B "Livestock and poultry excrement and urine treatment" for 6.04%, N_2O emissions from 3.B "Livestock and poultry excrement and urine treatment" for 2.81%, CO_2 emissions from 3.H "Urea use" for 1.24%, CH_4 emissions from 3.F "Burning of crop residues" for 0.12%, and N_2O emissions from 3.F "Burning of crop residues" for 0.04%.

From 2005 to 2016, GHG emissions in the agricultural sector fell around 11.00%, with an average annual growth rate of -1.05%. GHG emissions from 3.D "Agricultural soil" decreased 13.55%, with an average annual growth rate of -1.32%; 9.93% declined from 3.A "Gastrointestinal fermentation of livestock and poultry," with an average annual growth rate of -0.95%, and 0.99% fell from 3.C "Rice planting," with an average annual growth rate of -0.09%.

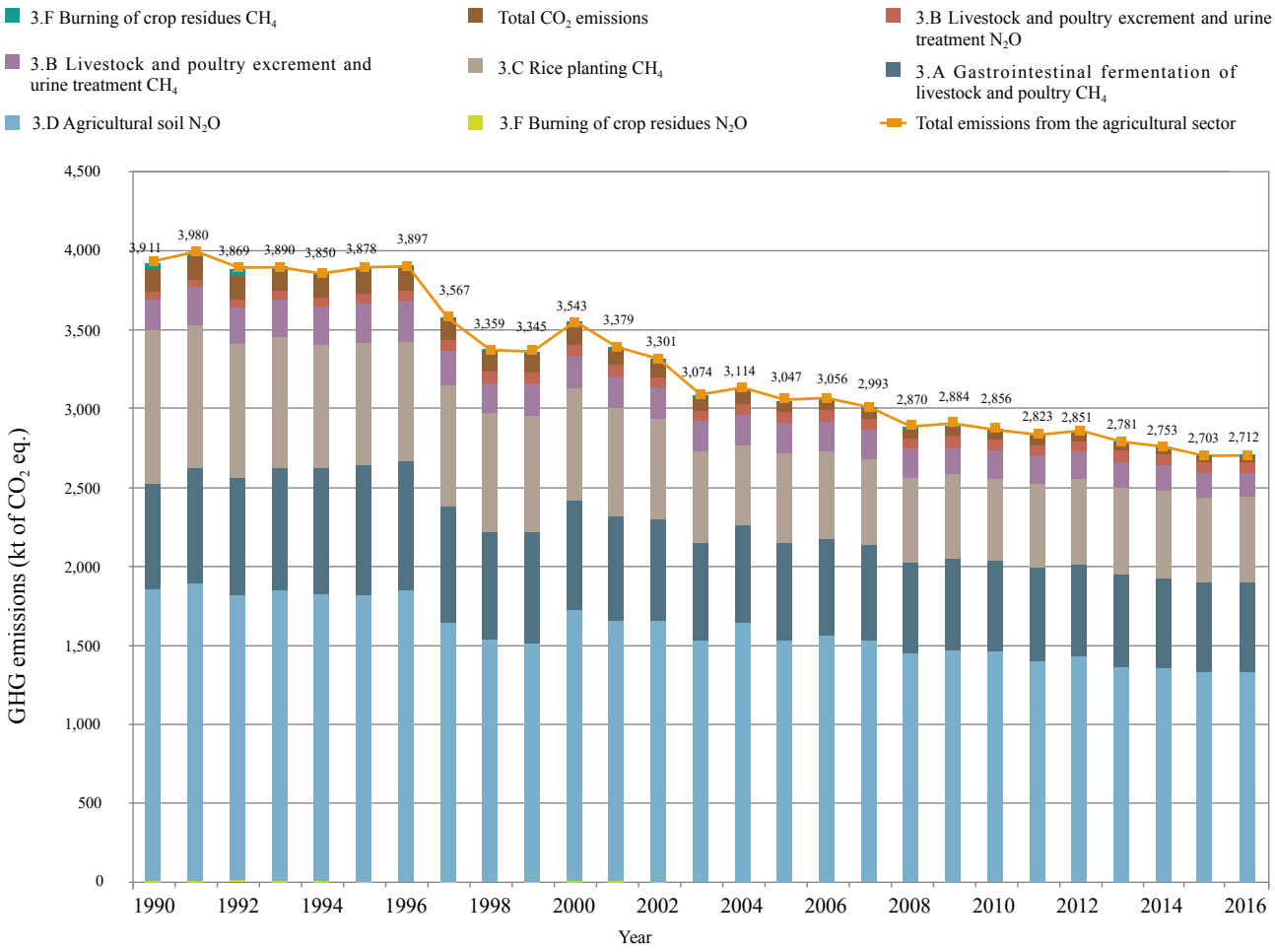


Figure 2.3.4 Trends in GHG emissions from Taiwan's agricultural sector from 1990 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.3.4 GHG emissions from Taiwan's agricultural sector from 1990 to 2016

(Unit: kt of CO_2eq.)

GHG emission sources and absorption sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total CO_2 emissions	142	146	139	131	135	151	151	134	127
Total CH_4 emissions	1,873	1,901	1,864	1,863	1,832	1,855	1,839	1,723	1,622
3.A Gastrointestinal fermentation of livestock and poultry	670	731	738	775	789	822	822	732	674
3.B Livestock and poultry excrement and urine treatment	206	236	234	240	247	259	266	219	192
3.C Rice planting	960	908	845	825	775	767	745	765	751
3.F Burning of crop residues	38	25	48	22	21	7	7	7	6
Total N_2O emissions	1,897	1,933	1,866	1,897	1,883	1,872	1,907	1,710	1,609
3.B Livestock and poultry excrement and urine treatment	48	50	52	54	59	61	67	70	71
3.D Agricultural soil	1,837	1,876	1,800	1,837	1,818	1,808	1,838	1,638	1,536
3.F Burning of crop residues	12	8	15	7	7	2	2	2	2
Total emissions from the agricultural sector	3,911	3,980	3,869	3,890	3,850	3,878	3,897	3,567	3,359
GHG emission sources and absorption sinks	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total CO_2 emissions	119	131	94	93	83	84	62	60	58
Total CH_4 emissions	1,644	1,618	1,565	1,479	1,394	1,320	1,387	1,368	1,341
3.A Gastrointestinal fermentation of livestock and poultry	694	692	660	636	626	614	623	614	609
3.B Livestock and poultry excrement and urine treatment	205	210	201	194	192	193	195	195	185
3.C Rice planting	738	702	689	637	567	505	561	551	543
3.F Burning of crop residues	7	14	15	13	9	8	8	8	5
Total N_2O emissions	1,583	1,794	1,720	1,729	1,597	1,710	1,598	1,629	1,595
3.B Livestock and poultry excrement and urine treatment	72	73	71	70	71	69	71	72	71
3.D Agricultural soil	1,509	1,717	1,644	1,655	1,524	1,639	1,524	1,554	1,522
3.F Burning of crop residues	2	4	5	4	3	2	2	3	1
Total emissions from the agricultural sector	3,345	3,543	3,379	3,301	3,074	3,114	3,047	3,056	2,993
GHG emission sources and absorption sinks	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total CO_2 emissions	57	56	54	53	55	45	40	38	34
Total CH_4 emissions	1,299	1,281	1,274	1,301	1,300	1,304	1,286	1,268	1,283
3.A Gastrointestinal fermentation of livestock and poultry	584	571	578	590	583	579	566	573	561
3.B Livestock and poultry excrement and urine treatment	180	175	176	180	172	166	164	163	164
3.C Rice planting	529	530	514	526	540	555	552	529	555
3.F Burning of crop residues	6	5	5	5	5	3	4	4	3
Total N_2O emissions	1,514	1,547	1,528	1,469	1,496	1,432	1,427	1,397	1,395
3.B Livestock and poultry excrement and urine treatment	72	71	70	71	71	71	73	74	76
3.D Agricultural soil	1,440	1,474	1,456	1,396	1,424	1,359	1,353	1,321	1,318
3.F Burning of crop residues	2	2	2	2	2	1	1	1	1
Total emissions from the agricultural sector	2,870	2,884	2,856	2,823	2,851	2,781	2,753	2,703	2,712

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

4. Land use, land-use change and forestry sector

Carbon dioxide (CO_2) is the main GHG removed by land use and forestry sector. The removal shows a slightly fluctuating trend over the years. The annual removal remains stable, mainly due to the increase of the annual growth of forest resources, while the removal from afforestation and forest disturbance is minor. In terms of the annual changes in the total removal by forest resources over the years, the carbon losses caused by forest fires in 2001 and 2009 were high, with the removal of 21,490 and 21,583 kt of CO_2eq respectively, and the values remaining stable for the rest of the years, as shown in Figure 2.3.5 and Table 2.3.5. The removal of GHGs in the land use and forestry sector in 2016 was 21,418 kt of CO_2eq, 0.03% down on 2015. CO_2 removal decreased by about 2.28% from 2005 to 2016, with an average annual growth rate of -0.21%.

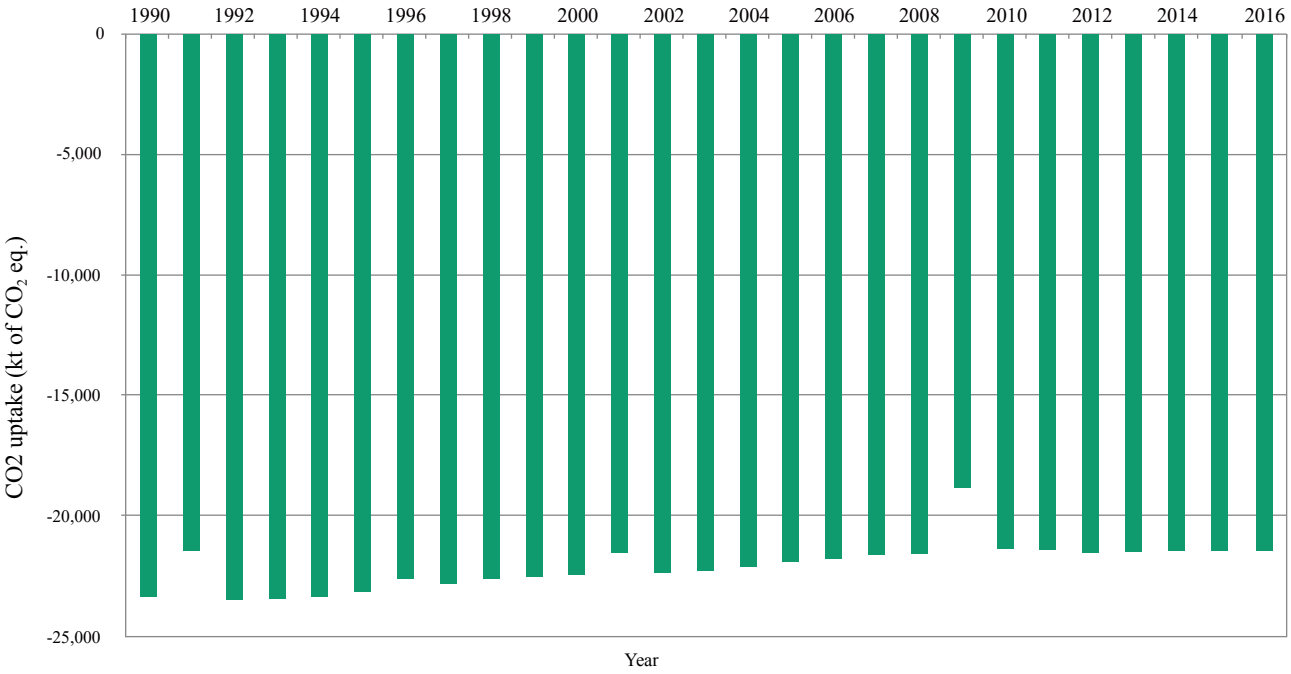


Figure 2.3.5 Trends in carbon removal in the land use, land-use change and forestry sector in Taiwan from 1990 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.3.5 Changes in carbon removal in Taiwan's forestry sector from 1990 to 2016

(Unit: kt of CO_2eq.)

Year	Woodland maintained as woodland		Other lands converted to woodland	Total removal (△ CO_2)
	Biomass carbon removal (△ CO_2 G)	Biomass carbon emissions(△ CO_2 L)	Biomass carbon removal (△ CO_2 G)	
1990	-23,902	607	-91	-23,386
1991	-23,902	2,503	-91	-21,490
1992	-23,713	333	-136	-23,516
1992	-23,524	216	-185	-23,493
1994	-23,335	190	-233	-23,379
1995	-23,146	202	-288	-23,233
1996	-22,957	559	-319	-22,717
1997	-22,768	266	-397	-22,899
1998	-22,579	326	-446	-22,699
1999	-22,390	401	-561	-22,550
2000	-22,201	389	-665	-22,476
2001	-22,012	1,112	-683	-21,583
2002	-21,823	167	-759	-22,415
2003	-21,633	227	-899	-22,305
2004	-21,444	243	-995	-22,196
2005	-21,255	369	-1,031	-21,918
2006	-21,066	251	-1,046	-21,861
2007	-20,877	308	-1,080	-21,650
2008	-20,688	199	-1,142	-21,631
2009	-20,499	2,753	-1,166	-18,911
2010	-20,392	218	-1,240	-21,413
2011	-20,409	140	-1,202	-21,470
2012	-20,435	145	-1,283	-21,572
2013	-20,473	135	-1,226	-21,564
2014	-20,508	197	-1,166	-21,477
2015	-20,546	189	-1,148	-21,505
2016	-20,542	153	-1,029	-21,418

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

5. Waste sector

The GHGs produced by the waste sector were made of CO_2, CH_4, and N_2O. GHG emissions in the sector have gradually declined in recent years, as shown in Figure 2.3.6 and Table 2.3.6. In 2016, emissions of 4,029 kt of CO_2eq accounted for about 1.37% of Taiwan's total GHG emissions, of which CH_4 emissions from 5.D "Wastewater treatment and discharge" accounted for 64.49% of GHG emissions from the agricultural sector, which constituted the largest proportion, followed by CH_4 emissions from 5.A "Solid waste treatment" for 23.57%, and N_2O emissions from 5.D "Wastewater treatment and discharge" for 7.59%. Emissions in 2016 were 1.94% lower than that in 2015. After 2000, CH_4 emissions have declined dramatically, mainly due to the implementation of waste reduction, resulting in a substantial decrease of sanitary and general landfill volumes, along with the promotion of biogas (CH_4) recovery measures. In 2016, the largest proportion of the waste sector's emissions was methane (64.50%) from 5.D “Wastewater treatment and discharge,” followed by methane emissions (23.57%) from 5.A “Solid waste treatment”. In 2016, the largest reduction was methane from 5.A “Solid waste treatment,” which accounted for 16.67% compared with 2015, as a result of the continuous reduction of landfill volumes nationwide.

From 2005 to 2016, the GHG emissions from the waste sector dropped approximately 53.90%, with an average annual growth rate of -6.80%; 7.15% down for 5.D "Wastewater treatment and discharge," with an average annual growth rate of -0.67%, 81.80% down for 5.A "Solid waste treatment," with an average annual growth rate of -14.35%, 63.36% down for 5.C "Waste incineration and open burning," with an annual average growth rate of - 8.72%.

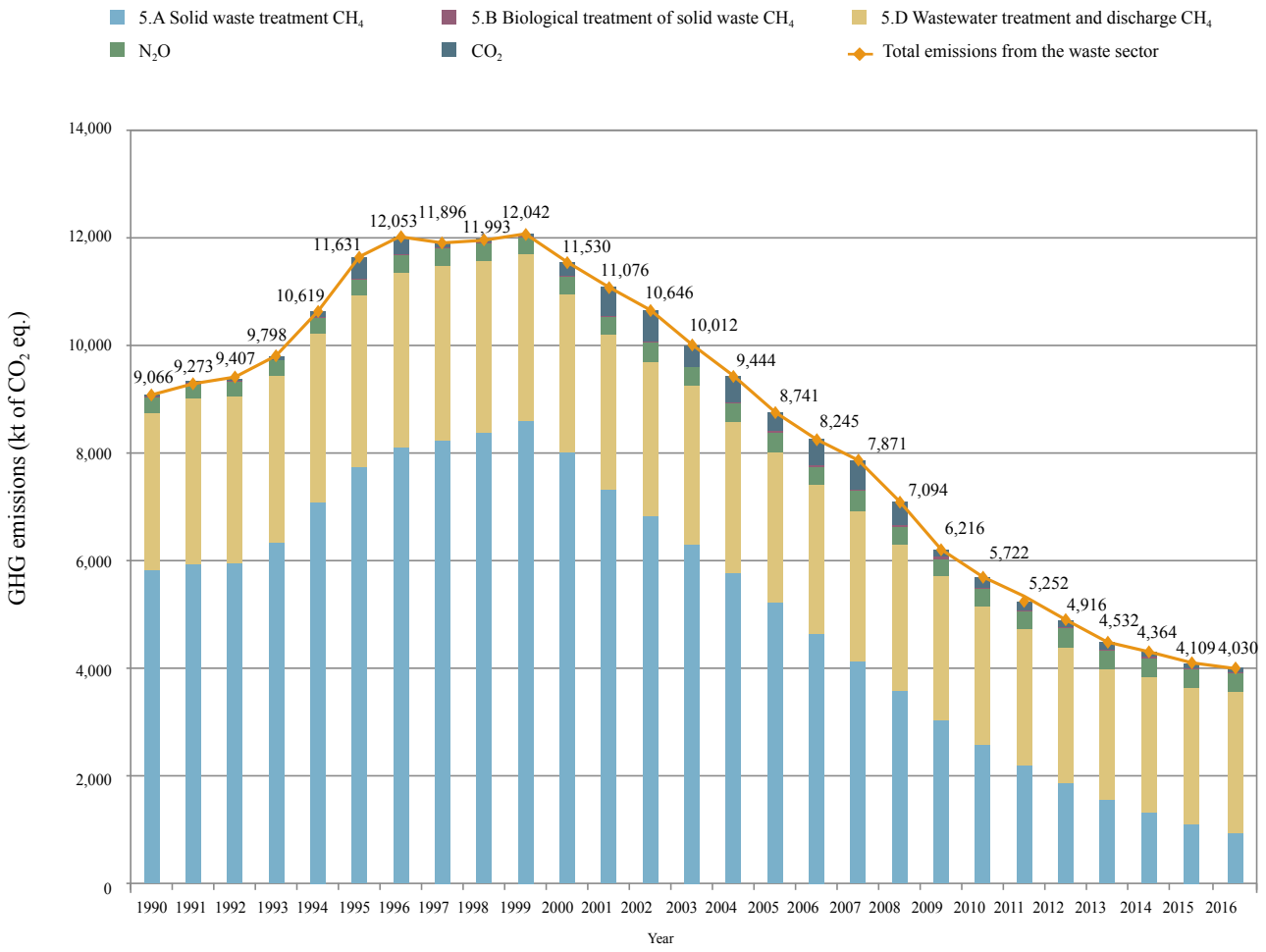


Figure 2.3.6 Trends in GHG emissions from Taiwan's waste sector from 1990 to 2016

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

Table 2.3.6 GHG emissions from Taiwan's waste sector from 1990 to 2016

(Unit: kt of CO_2 eq.)

GHG emission sources and absorption sinks	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total CO_2 emissions	20	8	65	63	110	398	387	105	117
Total CH_4 emissions	8,750	8,980	9,044	9,423	10,196	10,899	11,329	11,454	11,556
5.A Solid waste treatment	5,832	5,917	5,928	6,323	7,061	7,719	8,080	8,212	8,372
5.B Biological treatment of solid waste	11	1	1	0	0	1	0	1	0
5.D Wastewater treatment and discharge	2,907	3,062	3,115	3,100	3,135	3,179	3,249	3,241	3,184
Total N_2O emissions	296	285	298	311	313	334	337	337	321
5.B Biological treatment of solid waste	10	0	1	0	0	1	0	1	0
5.C Incineration and open burning of waste	1	0	4	3	6	18	19	4	6
5.D Wastewater treatment and discharge	285	284	294	307	307	316	318	332	315
Total emissions from the waste sector	9,066	9,273	9,407	9,798	10,619	11,631	12,053	11,896	11,993
GHG emission sources and absorption sinks	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total CO_2 emissions	65	259	540	612	417	512	348	470	562
Total CH_4 emissions	11,648	10,941	10,196	9,686	9,242	8,588	8,043	7,425	6,948
5.A Solid waste treatment	8,604	8,024	7,305	6,821	6,310	5,763	5,219	4,656	4,135
5.B Biological treatment of solid waste	2	0	0	0	2	7	10	11	14
5.D Wastewater treatment and discharge	3,042	2,916	2,891	2,864	2,930	2,818	2,815	2,757	2,798
Total N_2O emissions	329	331	340	348	353	343	350	351	360
5.B Biological treatment of solid waste	2	0	0	0	2	6	9	10	13
5.C Incineration and open burning of waste	3	8	30	26	24	23	27	30	30
5.D Wastewater treatment and discharge	324	322	310	321	327	314	314	310	318
Total emissions from the waste sector	12,042	11,530	11,076	10,646	10,012	9,444	8,741	8,245	7,871
GHG emission sources and absorption sinks	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total CO_2 emissions	443	154	208	149	149	153	146	103	131
Total CH_4 emissions	6,322	5,735	5,177	4,758	4,423	4,027	3,854	3,643	3,568
5.A Solid waste treatment	3,601	3,066	2,597	2,222	1,887	1,595	1,349	1,140	950
5.B Biological treatment of solid waste	16	18	21	26	24	23	20	20	20
5.D Wastewater treatment and discharge	2,705	2,651	2,559	2,510	2,512	2,410	2,484	2,484	2,599
Total N_2O emissions	328	327	337	346	344	352	364	363	330
5.B Biological treatment of solid waste	15	16	19	23	22	20	18	18	18
5.C Incineration and open burning of waste	21	9	11	9	9	9	9	6	6
5.D Wastewater treatment and discharge	293	302	307	313	314	323	337	339	306
Total emissions from the waste sector	7,094	6,216	5,722	5,252	4,916	4,532	4,364	4,109	4,029

Source: Taiwan Environmental Protection Administration. 2018 Taiwan Greenhouse Gas Inventory Report.

2.4 Analysis of key sources and trends of GHGs

The screening of Taiwan's key GHG emission sources is mainly based on level assessment and trend assessment, which are the first-level methods from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The level assessment method is primarily based on the estimated proportion of each emission source in the total GHG emissions of the same year, arranged in descending order of size, and then accumulated to 95%. The above emission sources are the key ones of the year. When the data from the level assessment are not big enough to be identified as a key source, but the trend is different from that of national inventory data and inventory data for over a year can be obtained, the trend estimates of various emission sources can be arranged in descending order according to the contribution of various emission sources trends to the overall inventory trend, accumulating the estimated value to 95%. The above emission sources are the key ones for the overall inventory trend.

Based on the nation's 2016 emission data, we estimated the level of GHG inventory emissions. The key emission sources for the year consisted of 1.A.1 “Energy industry,” 1.A.2 “Manufacturing industry and construction,” 1.A.3 “Transportation,” 1.A.4 “Other sectors” (including 1.A.4.b "Housing" and 1.A.4.a “Service industry"), 2.C.1 “Iron and steel production," and 2.A.1 “Cement production,” whose cumulative emissions amounted to 95% of the total GHG emissions in 2016. Four out of six came from fuel combustion in the energy sector and the other two from the industrial processes and product use sector. Based on the above analysis results, the first three key emission sources in Taiwan were all caused by fuel burning, with carbon dioxide (CO_2) as the main GHG emitted.

In addition, according to the 2006 IPCC Guidelines, the trend estimation analysis of GHG emissions from 2005 to 2016 was carried out, with the results indicating that the emission sources affecting the variations in the emissions during this period were ranked in order of the percentage of trend estimates as follows: 1.A.1 “Energy industry,” 2.A.1 “Cement production,” 5.A.1 “Managed waste treatment plant site,” 1.A.2 “Manufacturing and construction industries,” 1.A.4 “Other sectors,” 2.C.1 “Iron and steel production,” 2.E.1 “Integrated circuit or semiconductor,” 2.G.2 “Other products using SF_6 and PFCs,” 2.C.4 “Magnesium production,” 2.E.2 “TFT flat-panel display,” 5.A.2 “Unmanaged waste treatment plant site,” 5.D.1 “Domestic sewage treatment and discharge,” 2.F.1 “Refrigeration and air conditioning,” and 2.A.4 “Other carbonate processes,” which were the key emission sources influencing the trend in GHG emissions in Taiwan from 2005 to 2016.

According to the comprehensive level assessment and trend assessment analysis results, the major key emission sources in Taiwan were 1.A.1 "Energy industry," 1.A.2 "Manufacturing industry and construction," 1.A.3 "Transportation," and 1.A.4 "Other sectors" of the energy sector, which gives off GHGs from fuel combustion. However, the key sources affecting the trend in GHG emissions due to the increase of emissions from 2005 to 2016 were 1.A.1 “Energy industry,” 2.C.1 “Iron and steel production,” and 2.A.4 “Other carbonate processes.” The rest were key sources affecting the trend in GHG emissions due to the reduction of emissions.

Reference

1. Taiwan Environmental Protection Administration (2018), “2018 Taiwan Greenhouse Gas Inventory Report,” Taipei, Taiwan: Taiwan Environmental Protection Administration.

▲LaoMei Green Reef

Chapter 3
Taiwan's Greenhouse Gas Reduction Policies and Measures

Chapter 3
Taiwan's Greenhouse Gas Reduction Policies and Measures

Taiwan upholds the spirit and principles of the United Nations Framework Convention on Climate Change (UNFCCC). It has been paying close attention to the UNFCCC's regulatory development trend over the years and is committed to the domestic policies and measures for GHG reduction. This chapter introduces the nation's response position and the government's organizational structure, the focus and progress of relevant legislation on climate change issues or GHG reduction over the years and the ongoing policies and measures to demonstrate Taiwan's efforts and contributions in response to climate change and GHG mitigation.

3.1 Taiwan's position in response to climate change

To address climate change and GHG reduction issues, which are local, regional and international, Taiwan has always actively responded to relevant resolutions of the UNFCCC and promoted climate change policies and measures driven by the state and government. As instructed by President Tsai Ing-wen, Taiwan "will not be absent on the issues of combatting global warming and climate change," and "will regularly review the reduction targets of GHGs in accordance with the provisions of the COP21 Paris Agreement, and work with friendly countries to jointly maintain a sustainable Earth."

Taiwan has not only defined the issue of climate change as international cooperation and international responsibilities, but also endeavored to legalize internally the concept of the UNFCCC and in 2015 promulgated the "Greenhouse Gas Reduction and Management Act." In a positive and active manner, Taiwan has made a commitment to GHG reduction and climate action and incorporated the long-term national GHG reduction objectives into the law. In addition to taking joint responsibility to protect the Earth's environment, it is also our inescapable responsibility for the country's sustainable future and survival and development of the next generation.

3.2 Government's organizational structure

3.2.1 National Council for Sustainable Development of the Executive Yuan

1. Origin

To follow this global trend, Taiwan established in August 1994 the "Executive Yuan Global Change Policy Guidance Panel," which consisted of relevant heads of ministries and departments and experts and academics, with six working groups under, dealing with global environmental issues and sustainable development. In 1997, the former panel was approved to be upgraded to the National Council for Sustainable Development (NCSD) of the Executive Yuan, with the minister without portfolio appointed as the chairperson and the secretarial work dealt with by the EPA. In November 2002, the Basic Environment Act passed the third reading at the Legislative Yuan, Article 29 of which gave the NCSD a legal status. The NCSD was upgraded from a task force to a statutory committee.

2. Organizational structure

Since the establishment of the NCSD, its working groups have changed multiple times as needed. In 2017, the NCSD set up seven working groups and two task forces: (1) health and welfare working group, (2) life and education working group, (3) green economy working group, (4) green transport working group, (5) land resources and urban and rural development working group, (6) sustainable agriculture and biodiversity working group, (7) environmental quality working group, (8) climate change and energy and carbon reduction task force, and (9) nuclear-free homeland promotion task force. The organizational structure of the NCSD is shown in Figure 3.2.1.

3. Promotion progress

The main sustainable development documents completed after the founding of the NCSD, include: (1) Agenda of the 21st Century—Strategy Programs for Taiwan's Sustainable Development completed in May 2000; (2) Action Plan for Sustainable Development completed in December 2001; (3) Declaration on Sustainable Development of Taiwan in January 2003; (4) Sustainable Development Indicators System in June 2003; (5) Agenda of the 21st Century in Taiwan—National Sustainable Development Vision and Strategy Program in November 2004; (6) Sustainable Development Policy Program in September 2009; (7) 2nd edition of Sustainable Development Indicators System in December 2009; and (8) Strategy and Direction of Promoting Green Economy in June 2015.

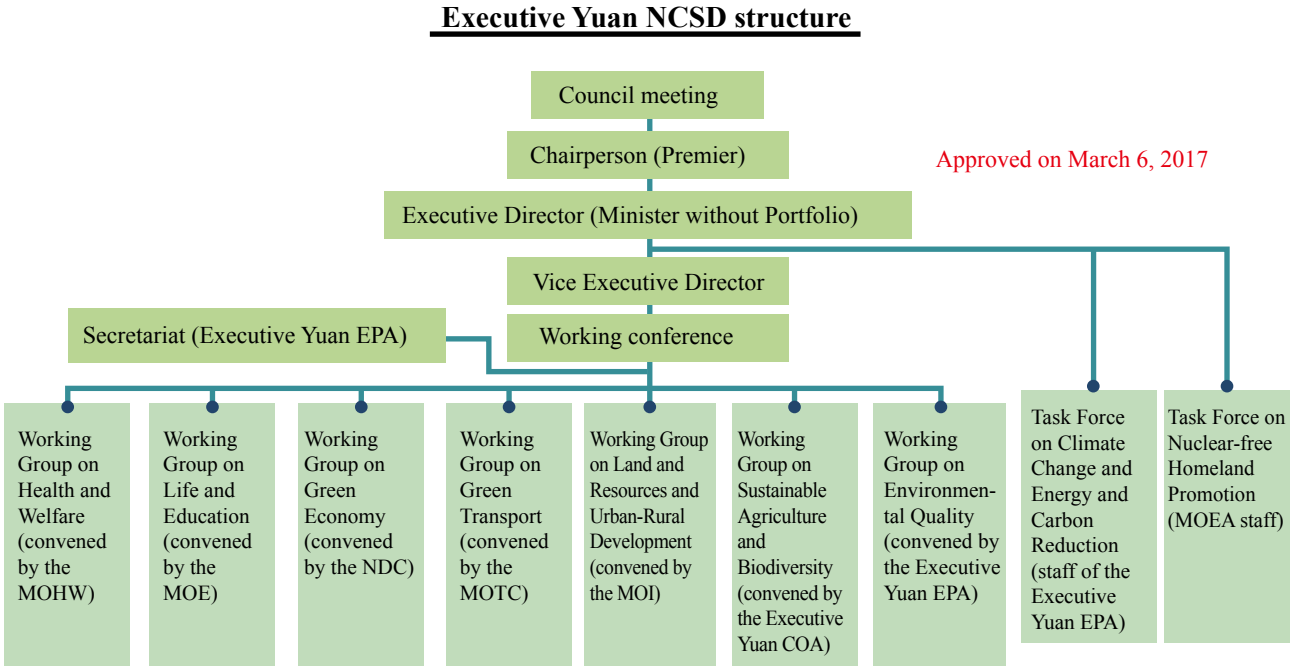


Figure 3.2.1 Organization chart of the Executive Yuan NCSD

Source: Executive Yuan NCSD official website.

On the basis of the UN Sustainable Development Goals (SDG), the working groups under the NCSD had worked out a draft of Taiwan's SDGs with 2030 as a target year. In 2017, they issued a Voluntary National Review (VNR) report on the nation's SDGs. The report described the implementation of important policies formulated by the UN SDGs, and the development of localized SDGs and sub-goals by referring to the UN's 17 SDGs and 169 sub-goals through various procedures like citizen participation and social dialogue.

3.2.2 Executive Yuan Energy and Carbon Reduction Office

1. Origin

Following several reorganizations and adjustments, Taiwan's organization on GHG reduction and energy issues established the Executive Yuan Energy Conservation and Carbon Reduction Promotion Committee in 2009, which was renamed the Executive Yuan Green Energy and Low Carbon Promotion Committee in 2014. Recently, in response to the situation at home and abroad, the Executive Yuan established the Energy and Carbon Reduction Office on June 7, 2016 pursuant to the Guidelines for the Establishment of the Executive Yuan Energy and Carbon Reduction Office to plan and integrate national energy policy, promote energy transition and GHG reduction, coordinate with ministries and departments on related affairs. The office bears the task to deliberate and formulate national energy policy, coordinating and promoting laws and regulations on national energy and GHG reduction, reviewing and tracking major energy and GHG reduction-related projects, coordinating with ministries and departments on energy and GHG reduction, organizing meetings on major energy and GHG reduction strategies, and reporting regularly to the premier on the progress of energy and GHG reduction policies.

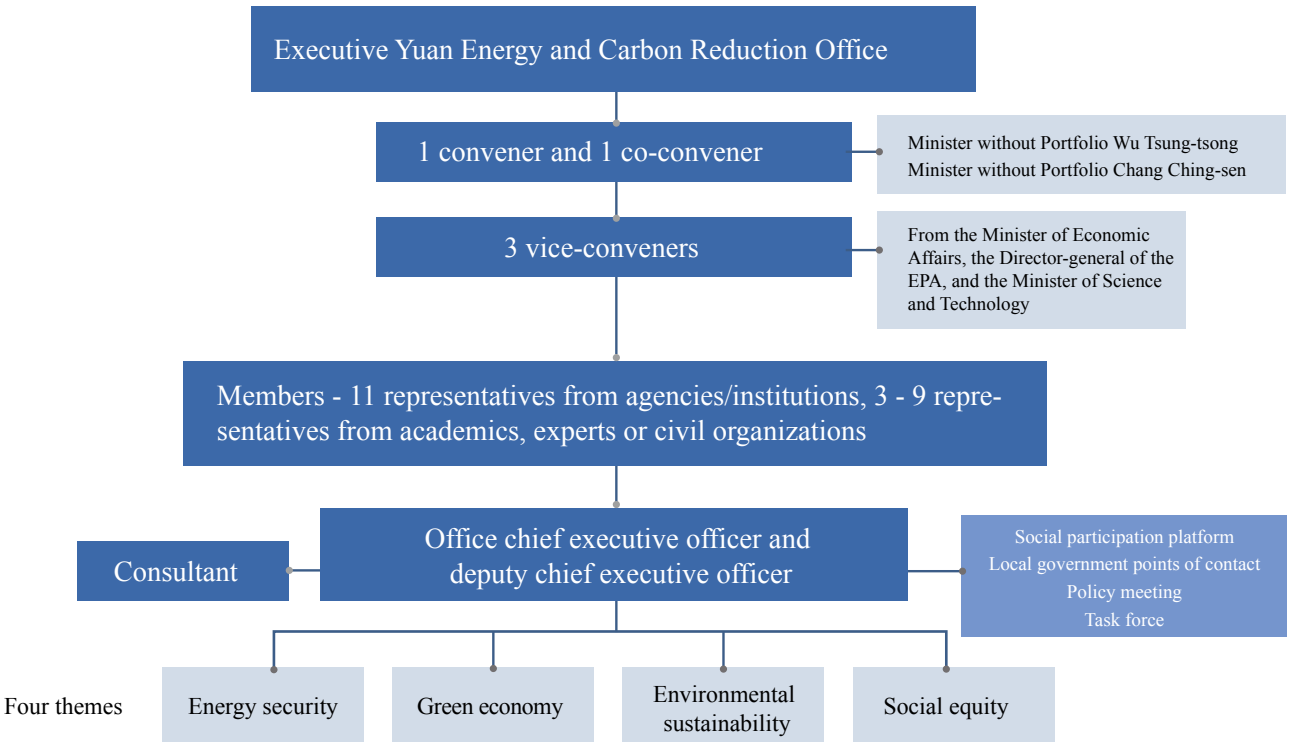


Figure 3.2.2 Organization chart of the Executive Yuan Energy and Carbon Reduction Office

Source: Executive Yuan NCSD official website.

2. Organizational structure

The Executive Yuan Energy and Carbon Reduction Office is staffed by one convener and one co-convener, each of whom is appointed by the premier among the ministers without portfolio responsible for energy or science and technology affairs, by three vice-conveners from the Minister of Economic Affairs, the Director-general of the EPA and the Minister of Science and Technology, and 19 to 25 members (the maximum number of members increased from 21 to 25, as amended on July 26, 2016). Except for the ex officio members of the convener, co-convener and vice conveners, the other members are appointed (hired) by the Executive Yuan among: (1) deputy minister of the interior; (2) deputy minister of transportation and communications; (3) vice minister of the COA; (4) vice minister of the National Development Council; (5) vice minister of the Public Construction Commission; (6) deputy minister of the Atomic Energy Commission; (7) general manager of Taiwan Power Company; (8) general manager of China Steel Corporation; (9) general manager of CPC Corporation, Taiwan; (10) executive director of the National Energy Program; (11) executive director of the Executive Yuan Energy and Carbon Reduction Office; and (12) three to nine representatives from academics, experts or civil organizations. The organizational structure of the Energy and Carbon Reduction Office of the Executive Yuan is displayed in Figure 3.2.2.

3. Promotion progress

Since the establishment, the Executive Yuan Energy and Carbon Reduction Office has coordinated various ministries and departments to formulate and advocate the following projects: Green Energy Technology Industry Promotion Project (approved in October 2016), Solar PV 2-Year Promotion Project (revised and approved in October 2017), Intelligent Power Grid Master Plan (revised and approved in February 2017), Energy Administration Act and Energy Development Guidelines (revised and approved in April 2017), Forward-looking Infrastructure Program-Green Energy Construction (approved in April 2017), New Energy Saving Movement Plan (approved in July 2017), Wind Power Generation 4-Year Promotion Project (approved in August 2017), Green Financial Action Plan (approved in November 2017), Phase I Greenhouse Gas Control Target (approved in January 2018), and Greenhouse Gas Reduction Promotion Project (approved in March 2018), in an effort to lay out a clear path for development which ensures Taiwan's energy security, promotes green economy, and moves towards environmental sustainability.

3.2.3 Introduction to division of labor and operating mechanisms of the ministries under the Greenhouse Gas Reduction and Management Act

Although it is stipulated in Greenhouse Gas Reduction and Management Act that the central competent authority is the EPA, the work of carbon reduction involves all agencies of the central government and local government departments. For this reason, it is necessary to establish an intergovernmental inter-ministerial mechanism to promote the management of GHG reduction and a hierarchical and responsible mechanism between the central and local authorities.

1. Inter-ministerial division of powers and responsibilities

According to Article 8 of the GHG Reduction and Management Act, the central authorities concerned shall promote GHG Reduction and climate change adaptation for a total of 17 items.

On June 24, 2016, the Executive Yuan convened the "Conference on Division and Integration of Work on Promoting Greenhouse Gas Reduction and Climate Change Adaptation" to establish the division of work among the ministries (as shown in Table 3.2.1) for advocating matters under Article 8 thereof, with the central industry competent authorities charged with the nation's sectors under Article 9 thereof shown in Figure 3.2.3.

2. Hierarchical promotion by central and local governments

According to Article 9 of the Greenhouse Gas Reduction and Management Act, the central competent authority shall develop a National Climate Change Action Guideline and GHG Reduction Action Plan. The central industry competent authorities shall determine GHG Emission Control Action Programs for the sectors on the basis of the foregoing Action Plan. Moreover, pursuant to Article 15 thereof, special municipality, county and city competent authorities shall develop GHG control implementation plans in accordance with the aforesaid Action Plan and the Action Program. Further, the GHG Management Fund shall be set up thereunder for central and local government to promote GHG emissions reductions and adaptation to climate change. The central and local layered framework for promotion thereunder is exhibited in Figure 3.2.4.

Table 3.2.1 Promotion, practice, and work division under Article 8 of the Greenhouse Gas Reduction and Management Act

	Promotion matters under Article 8 of the Greenhouse Gas Reduction and Management Act	GHG Emission Control Action Programs (by sector)	Central industry competent authorities
1	Development of renewable energy and energy technology	Energy	MOEA
2	Improvement of energy efficiency and energy conservation		
3	Reduction in GHG emissions by industrial sectors	Manufacturing	MOEA MOST
4	Transportation management, development of mass transit systems, and reduction in GHG emissions by other transportation sectors	Transportation	MOTC
5	Implementation of low carbon energy transportation		
6	Reduction and management of GHG emissions from buildings	Residential and commercial	MOI MOEA
7	Waste recycling and reuse	Environment	EPA
8	Forest resource management, biodiversity conservation, and strengthening of forests' carbon sequestration	Agriculture	COA
9	Reduction and management of GHG emission from agriculture and guarantee of food security		

Source: Executive Yuan EPA website on national regulations on GHG reduction.

Greenhouse Gas Reduction and Management Act

Article 8
Relevant central government agencies shall promote GHG reduction and climate change adaptation through the following actions:

On June 24, 2016, the Executive Yuan convened the "Conference on Division and Integration of Work on Promoting GHG Reduction and Climate Change Adaptation" to establish the division of promotion work among the ministries under Article 8 thereof and the central industry competent authorities charged with the nation's sectors under Article 9 thereof

	Promotion matters	Competent authorities	Assisting authorities
1	Development of renewable energy and energy technology	MOEA	MOST
2	Improvement of energy efficiency and energy conservation	MOEA	Industry competent authorities
3	Reduction in GHG emissions by industrial sectors	MOEA	MOST
4	Transportation management, development of mass transit systems, and reduction in GHG emissions by other transportation sectors	MOTC	MOEA
5	Implementation of low carbon energy transportation	MOTC	MOEA, EPA
6	Reduction and management of GHG emissions from buildings	MOI	MOEA
7	Waste recycling and reuse	EPA	Industry competent authorities
8	Forest resource management, biodiversity conservation, and strengthening of forests' carbon sequestration	COA	MOI
9	Reduction and management of GHG emission from agriculture and guarantee of food security	COA	-
10	Green finance and GHG reduction incentive mechanisms	NDC	FSC, MOF
11	Assessment of impact of GHG reduction on the economy as a whole and planning of response measures	NDC	MOEA
12	Establishment of GHG cap-and-trade scheme including allocation, auction, allowance sale, trade, and facilitation of international emission reduction cooperation mechanism	EPA	MOEA, FSC, MOFA
13	Research, development and implementation of GHG reduction technologies	MOEA	MOST
14	Study of international GHG conventions and laws and participation in international conferences	EPA	Industry competent authorities
15	Development and implementation of matters connected with climate change adaptation	NDC, EPA	Industry competent authorities
16	Education and advocacy of climate change adaptation and GHG reduction	EPA, MOE	Industry competent authorities
17	Other climate change adaptation and GHG reduction matters	EPA	-

Figure 3.2.3 Division of promotion work among the ministries under the Greenhouse Gas Reduction and Management Act

Source: Executive Yuan EPA website on national regulations on GHG reduction.

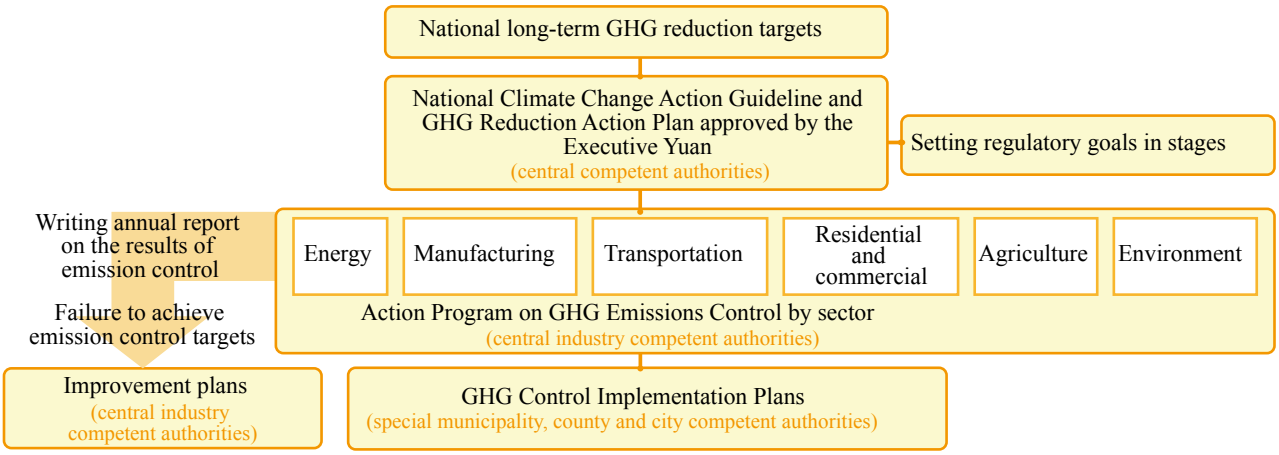


Figure 3.2.4 Hierarchical promotion framework for central and local governments under the Greenhouse Gas Reduction and Management Act

Source: Executive Yuan NCSD official website.

3.3 Greenhouse Gas Reduction and Management Act

1. Brief Introduction to the Act

The Greenhouse Gas Reduction and Management Act (the Act) was promulgated by the President on July 1, 2015. The legislative principles of the Act are based on the philosophy of the United Nations Framework Convention on Climate Change (UNFCCC), assuming common but differentiated responsibilities, implementing environmental justice, fulfilling joint responsibility for protecting the Earth's environment, and ensuring the sustainable development of the country. The Act regulates the nation's long-term reduction objectives, the powers and responsibilities of government agencies, GHG reduction measures and educational promotion. As a bridge between domestic integration of decision-making mechanisms and future engagement in international cooperation, the Act consists of six chapters, totaling 34 articles: Chapter 1 General Principles with 7 articles, Chapter 2 Authority and Responsibility of Government Agencies with 8, Chapter 3 Emission Reduction Measures with 8, Chapter 4 Education and Grants with 4, Chapter 5 Penalty Provisions with 5, and Chapter 6 Supplementary Provisions with 2. Its architecture is shown in Figure 3.3.1.

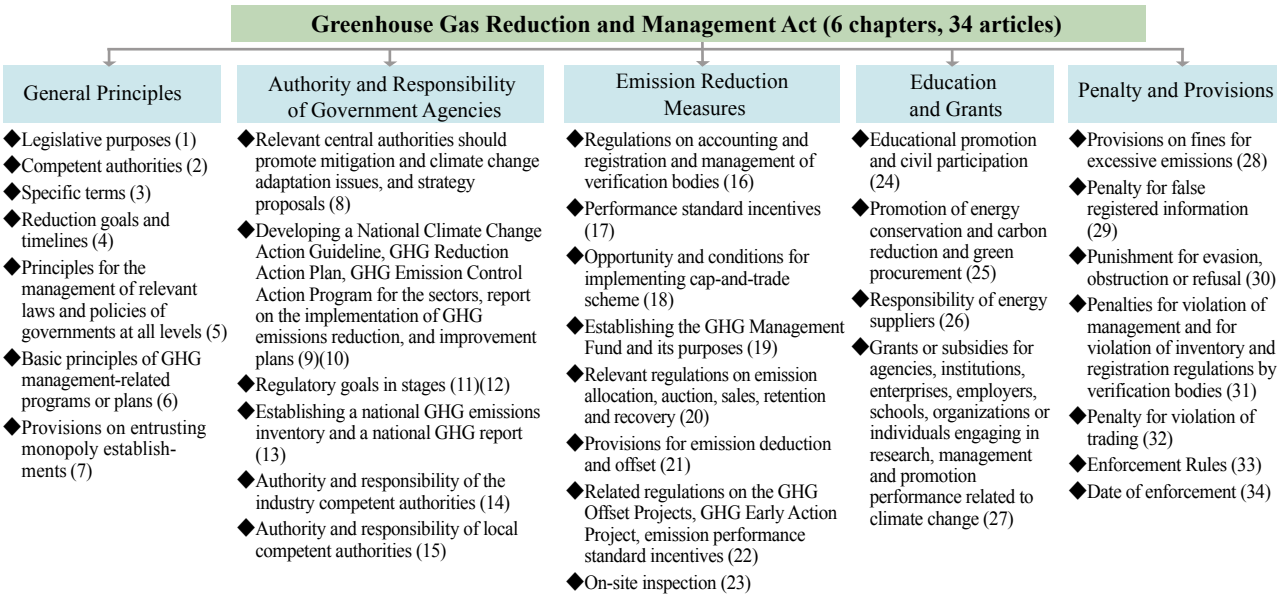


Figure 3.3.1 Greenhouse Gas Reduction and Management Act framework

Source: Executive Yuan EPA website on national regulations on GHG reduction.

2. Establishing Long-term goal of cutting emissions

At present, countries incorporating the emission reduction target into the law include only the EU, Switzerland, the United Kingdom, France, Mexico, and Taiwan. Taiwan voluntarily fulfills the common but differentiated international responsibilities under the UNFCCC and is one of the few countries that have legalized the emission reduction target. According to Article 4 of the Act, long-term national GHG emission reduction goal shall be to reduce GHG emissions to no more than 50% of 2005 GHG emission by 2050. The goal shall be timely adjusted by taking into consideration the UNFCCC, its agreements or related international conventions and decisions, together with domestic circumstances.

3. Emission reduction measures under the Act

Following the promulgation of the Act, the primary task of the central competent authorities is to grasp the major emission sources and emissions through the accounting and registration system, in addition to encourage voluntary reduction actions in conjunction with incentives and subsidies mechanisms proposed by relevant ministries. Additionally, they have worked out emission source performance standards and related voluntary emission reduction incentive mechanisms with relevant ministries to prompt entities to reduce emissions as soon as possible. When the relevant mechanisms are complete and in place, they will develop the promotion schedule of the total volume control and emission trading system in the light of the international climate negotiations and the principle of maintaining the nation's industrial competitiveness. Emission sources are announced in different stages and total emission targets will be set out for each stage, which are implemented in phases through flexible mechanisms such as trading and project exchange. The phase management of emission sources and an entity's reduction strategy is shown in Figure 3.3.2.

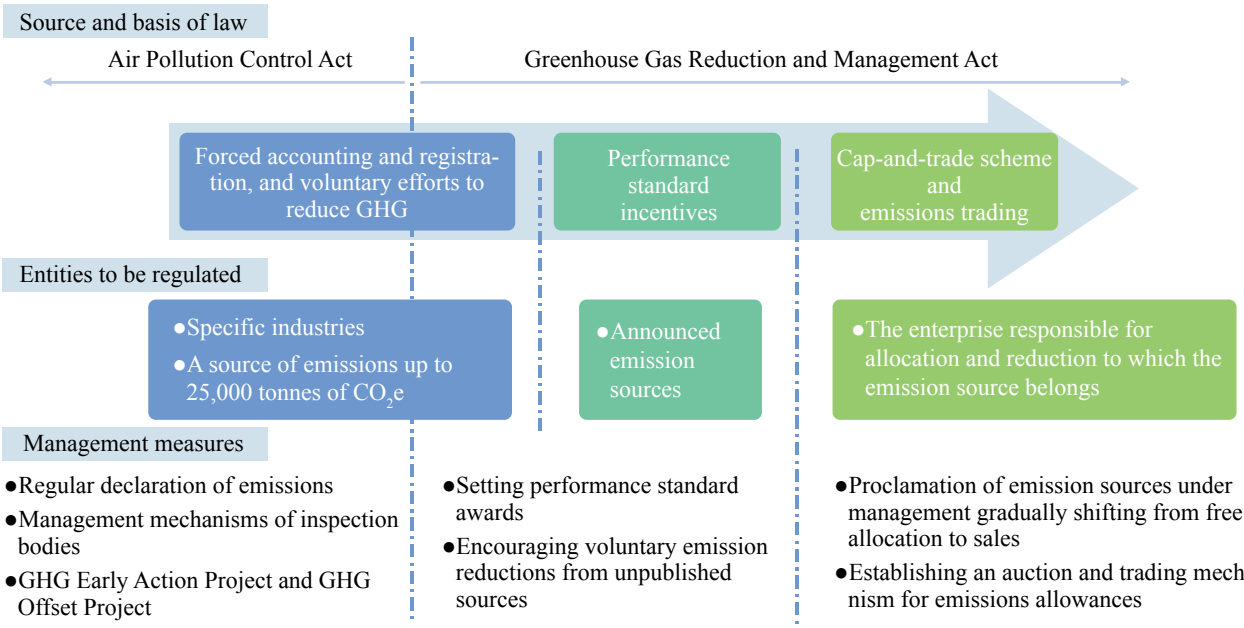


Figure 3.3.2 Phase management of emission sources and an entity's emission reduction strategy

Note: The EPA announced on May 9, 2012 that six GHGs, such as carbon dioxide, are air pollutants, and enacted relevant measures and administrative rules to implement GHG control in accordance with the Air Pollution Control Act. After the promulgation of the Greenhouse Gas Reduction and Management Act on July 1, 2015, the above-mentioned provisions have been abolished, with the Act governing the aspects.

Source: Executive Yuan EPA website on national regulations on GHG reduction.

4. Supporting acts

As of June 2018, the EPA has enacted 10 statutory orders and six administrative rules pursuant to the Act. Among them, the statutory orders include the following regulations concerning the emission reduction measures: the "Enforcement Rules of the Greenhouse Gas Reduction and Management Act," "Regulations for Periodic Regulatory Goals and Approaches of the Greenhouse Gas Emissions," "Regulations for the Management of Greenhouse Gas Emissions Accounting and Registration," "The First Batch of Greenhouse Gas Emission Sources that Should be Checked and Registered," "Regulations on the Administration of Greenhouse Gas Accreditation Bodies and Verification Bodies," "Regulation Governing the Greenhouse Gas Offset Project," "Incentives for Greenhouse Gas Emission Sources in Compliance with Performance Standards," "Regulations for the Custody and Utilization of Revenues and Expenditures of the Greenhouse Gas Management Fund," as well as the "Incentives for Reducing Greenhouse Gas Emissions in General Waste Landfills" and "Incentives for Low Carbon Products" that are related to educational promotion and rewards. The Act is combined with relevant supporting legislation to build a measurable, reportable and verifiable legal basis for carbon management, and promote the accounting and registration of emission sources, inspection and management, and GHG offset projects. Additionally, performance standards and incentive mechanisms for low-carbon products have been established to formulate emission source performance standards and incentive mechanisms for a voluntary reduction in conjunction with the incentive and subsidy criteria introduced by relevant ministries to encourage entities' reduction actions.

According to Article 9 of the Act, the central competent authority shall develop a National Climate Change Action Guideline (Action Guideline) and GHG Reduction Action Plan (Action Plan), and shall implement the Action Guideline and Action Plan in consultation with the central industry competent authorities after requesting approval from the Executive Yuan. The Action Guideline is the top general policy at the national level to cope with climate change, including two aspects: adaptation and mitigation. The Action Plan is at the central level, aiming at implementing the national reduction action, which includes the periodic regulatory goals and the division of authority and responsibility among government agencies. The GHG Emission Control Action Programs (Action Programs) are at the ministerial level, including energy, manufacturing, transportation, residential and commercial, agriculture and environment sectors. The ministries in charge are responsible for the division of reduction work among the sectors under their supervision, covering the GHG emissions target and economic incentive measures. The GHG Control Implementation Plans (Implementation Plans) are at the local level covering low-carbon sustainable cities and carry out the local reduction in accordance with the Action Plan and Action Program. The guideline, related actions and programs are shown in Figure 3.3.3.

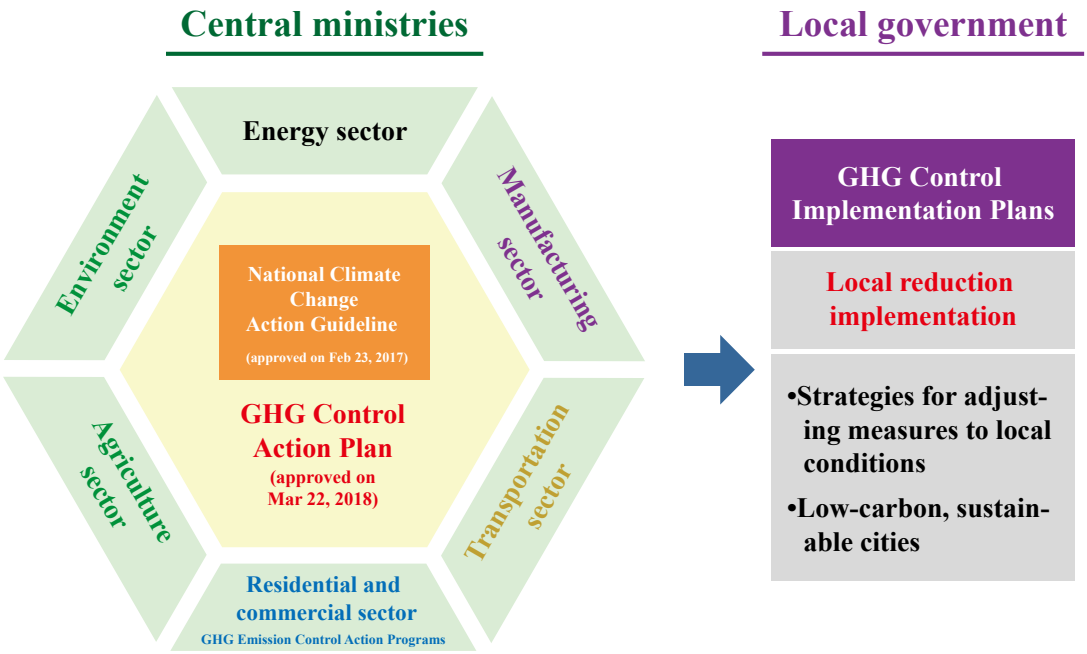


Figure 3.3.3 Hierarchical relations for the guideline and related actions and programs

Source: Executive Yuan EPA website on national regulations on GHG reduction.

3.3.1 National Climate Change Action Guideline

The Action Guideline, formulated by the EPA in accordance with Paragraph 1, Article 9 of the Act, was approved by the Executive Yuan on February 23, 2017, clearly defining the general policy for promoting GHG mitigation and climate change adaptation in Taiwan.

The basic principles of the Action Guideline proclaim our policy orientation in response to climate change, following the Paris Agreement and the Kigali Amendment to the Montreal Protocol, taking consideration of the common benefits of various environmental issues, promoting green finance and carbon pricing schemes and the vision of a nuclear-free homeland, incorporating adaptation and mitigation strategies into environmental impact assessments and resilient development, and keeping up with international standards.

Taking into account the Paris Agreement and the UN 2030 Sustainable Development Goals, the Action Guideline, in the spirit of mitigation and adaptation, sets out 10 basic principles for the nation's response to climate change. The policies include six sectors for GHG reduction and eight areas for climate change adaptation and policy support, together with the initiation of inter-sectoral response actions, intend to gradually improve Taiwan's ability to adapt to climate change, and strive to achieve its long-term goal of reducing GHG emissions, and to further ensure the country's sustainable development. The Action Guideline's framework and policy content are shown in Figure 3.3.4.

3.3.2 GHG Reduction Action Plan

The Action Plan, drawn up by the EPA in accordance with Paragraph 1, Article 9 of the Act, was approved by the Executive Yuan on March 22, 2018. Its content covers periodic regulatory goals, reduction strategies for energy, manufacturing, transportation, residential and commercial, agriculture and environment sectors, clear division of the authority and responsibility among the central ministries in promoting GHG reduction and capacity building, and evaluation indicators for reviewing work effectiveness of the sectors, The Act also includes eight inter-ministerial policies such as total volume control, green tax and fee system, green finance and green energy industry, impact assessment and technical R&D, information dissemination and incentive subsidies, climate talent cultivation and awareness enhancement, regulatory review and revision and sound financial mitigation mechanisms. The intention is for the integration of inter-ministerial synergies to cut carbon emissions and achieve the goal of carbon reduction by rolling review and intensification every five years. The framework of the GHG Reduction Action Plan is presented in Figure 3.3.5.

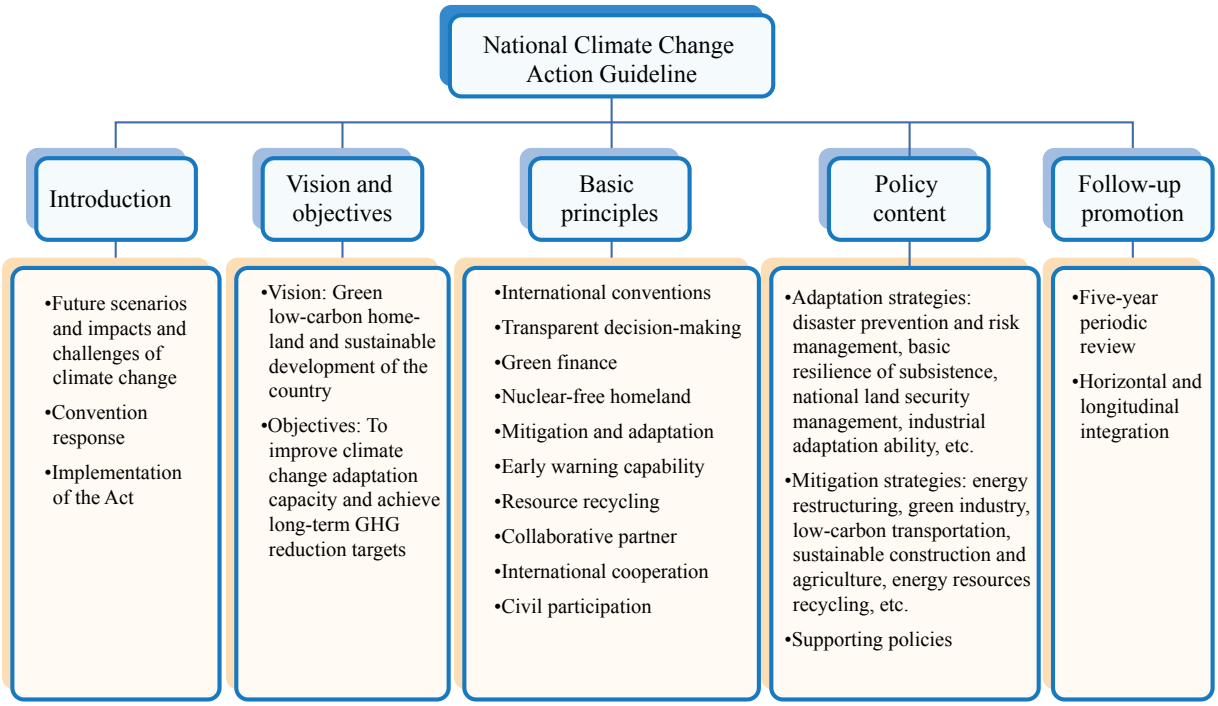


Figure 3.3.4 Framework of National Climate Change Action Guideline

Source: Executive Yuan EPA website on national regulations on GHG reduction.

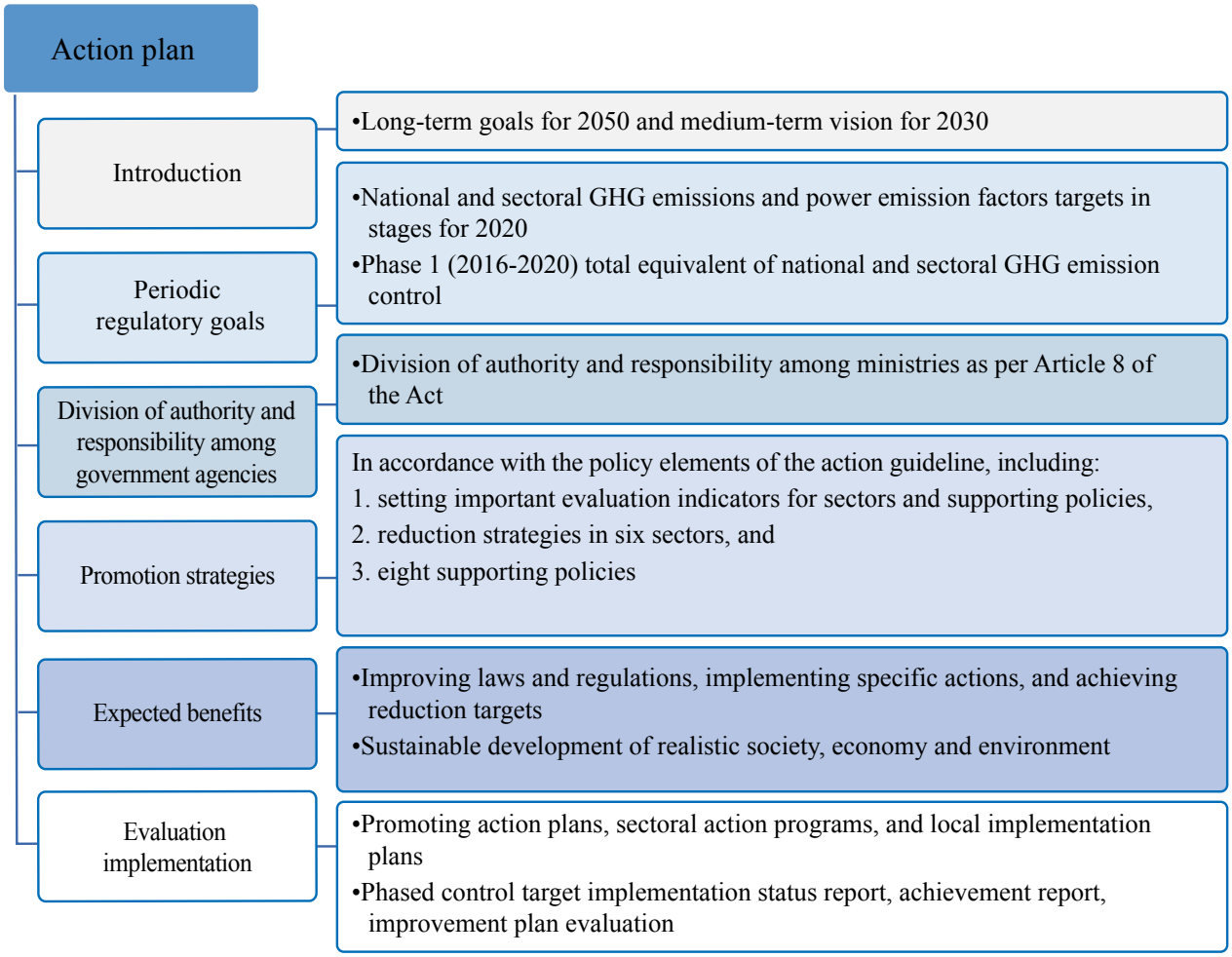


Figure 3.3.5 Framework of GHG Reduction Action Plan

Source: Executive Yuan EPA website on national regulations on GHG reduction.

The follow-up of the Action Plan will be promoted through the "GHG Emission Control Action Programs" for six sectors and the "GHG Control Implementation Plans" at the local government level. The relevant ministries will also regularly follow up and review the implementation of sector-based periodic regulatory goals, with the EPA reporting to the Executive Yuan annually. The following explanations are given for the periodic regulatory goals, six sectors' implementation strategies and eight supporting policies included in the Action Plan.

1. Periodic regulatory goals

The Action Plan covers the GHG periodic regulatory goals approved by the Executive Yuan, including national and sectoral GHG emissions by the target year, the total equivalent of GHG emission control during each period and the phase target of the power emission factor (kg CO_2eq/kWh). The regulatory goals are established in stages to achieve the national expected long-term GHG reduction. By referring to the Carbon Budget system in the UK Climate Change Act 2008, Article 11 of the Act stipulates that the central competent authorities shall set GHG periodic regulatory goals on a five-year basis and send them to the Executive Yuan for approval after a public hearing.

Furthermore, modelled on the UK's Committee on Climate Change (CCC), the central competent authority on March 24, 2016 invited scholars, experts, and non-governmental organizations, together with the central industry competent authorities, to form an advisory committee to set the regulations for the goals and regulatory approaches as the basis for the formulation of the regulatory goals in phases. In order to regularly track the implementation of the phased control goals and review and adjust them in a rolling manner, Article 12 of the Act stipulates that the implementation of the regulatory goals for each stage and the target review mechanism shall be reported annually to the Executive Yuan.

The EPA, in consultation with the central industry competent authorities, has established the first phase of the nation's GHG regulatory goals in phases, and on January 23, 2018, upon the approval of the Executive Yuan, will review the emission achievement status of each phase and make rolling adjustments. The base year of the national GHG reduction program is 2005, with the targets of each phase shown in Figure 3.3.6:

- Phase 1 (2016-2020) goal: 2% less than the base year by 2020
- Phase 2 (2021-2025) goal & vision: 10% less than the base year by 2025
- Phase 3 (2026-2030) goal & vision: 20% less than the base year by 2030, with rolling review

2. Six sectors' promotion strategies

Following the GHG mitigation policy laid down in the National Climate Change Action Guideline, the Action Plan has launched six sectors' promotion strategies and formulated sectoral evaluation indicators to facilitate the assessment and review of the implementation. The sectoral strategies and indicators are summarized in Figure 3.3.7.

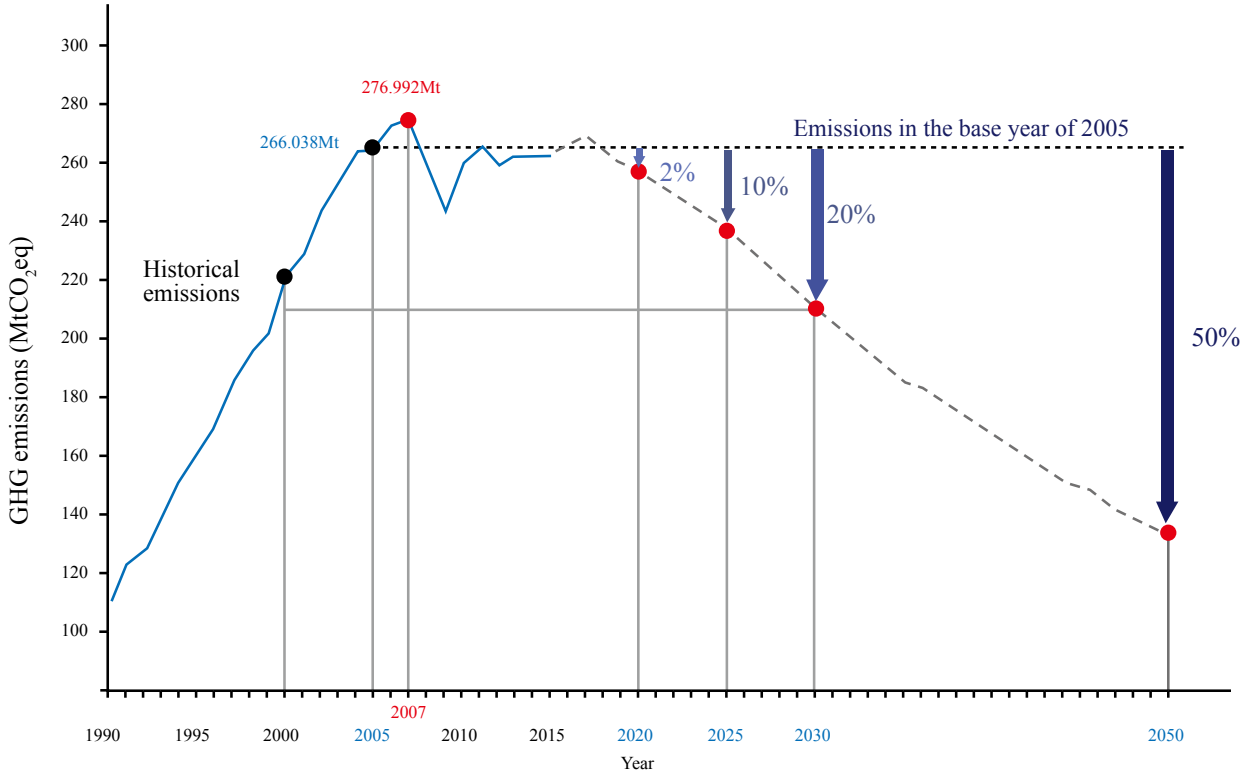


Figure 3.3.6 GHG reduction path in Taiwan

Source: Executive Yuan EPA website on national regulations on GHG reduction.

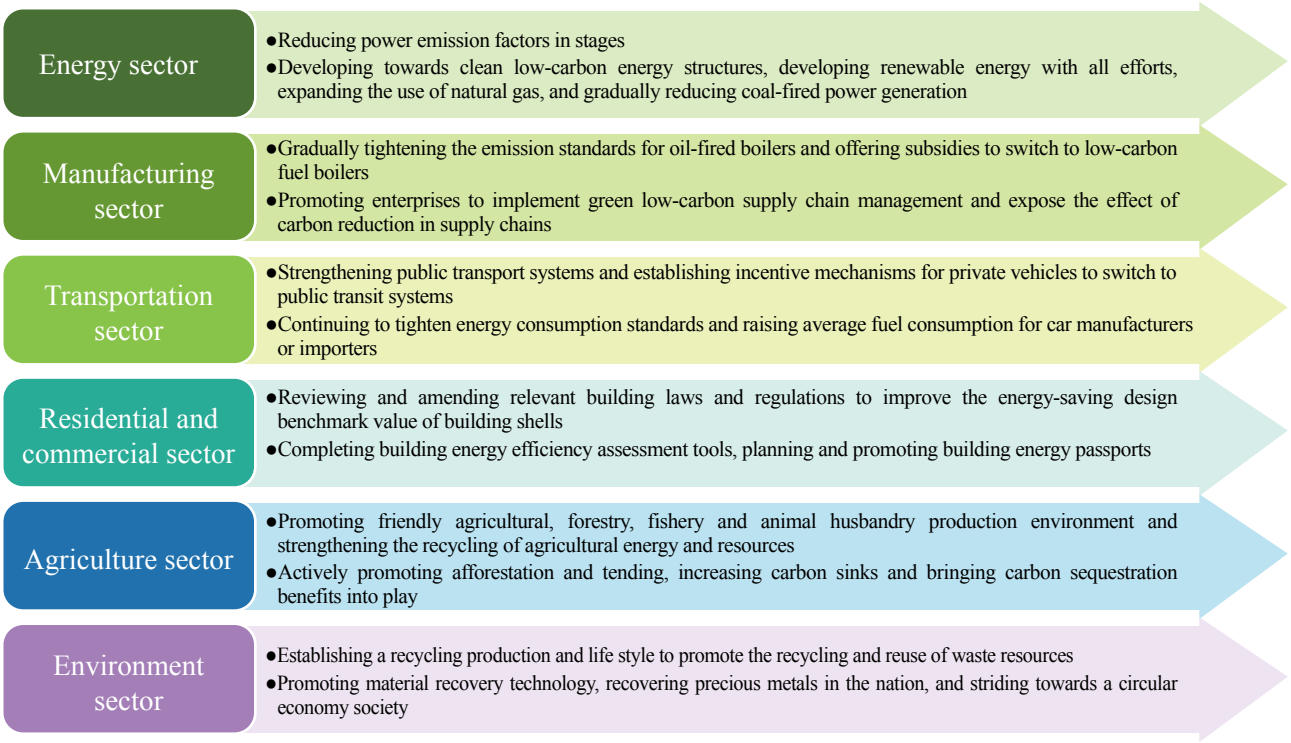


Figure 3.3.7 Six sectors' promotion strategies and objectives

Source: Executive Yuan EPA website on national regulations on GHG reduction.

3. Eight supporting policies

GHG reduction needs to be promoted through perfect laws and regulations, economic incentives and educational advocacy, and among which, the most important objective is the review of laws and regulations and the removal of institutional obstacles. It is hoped that by formulating or amending relevant regulatory and incentive laws and mechanisms and checking relevant fund sources, uses and amounts can the incentives and environment for GHG reduction be created to ensure that the reduction can be carried out thoroughly. The supporting policies and indicators are summarized in Figure 3.3.8.

Promoting total GHG control	Mastering baseline information on emission sources and establishing total control and emission trading systems.
Promoting green tax and fee systems	Discussing the possibility of levying energy or carbon taxes, and establishing a competitive and cooperative assessment and coordination mechanism for related taxes and fees.
Developing green finance and green energy industry	Promoting green financing and green bonds, activating the use of private funds, leading the development of green energy industry, and furthering the construction of low-emission resilience.
Responding to the impact of temperature reduction on economy and reduction technology R&D	Assessing the impact of GHG reduction on overall economy, and promoting R&D of GHG reduction technology.
Establishing information channels and providing incentives and subsidies	Establishing climate change information channels accessible to the public, providing incentives or subsidies, and propelling behavioral change for all.
Cultivating talents and raising public awareness and action	Promoting environmental education on climate change, cultivating talents to cope with climate change, and enhancing full awareness, skills and action.
Reviewing and amending relevant regulations on GHG reduction	Examining the impediments to the promotion system, and counting control and incentive mechanisms related to temperature reduction, to integrate and expand the promotion.
Improving the financial mechanism for climate change mitigation	Making an inventory of the sources, uses and amounts of relevant funds to promote climate change mitigation.

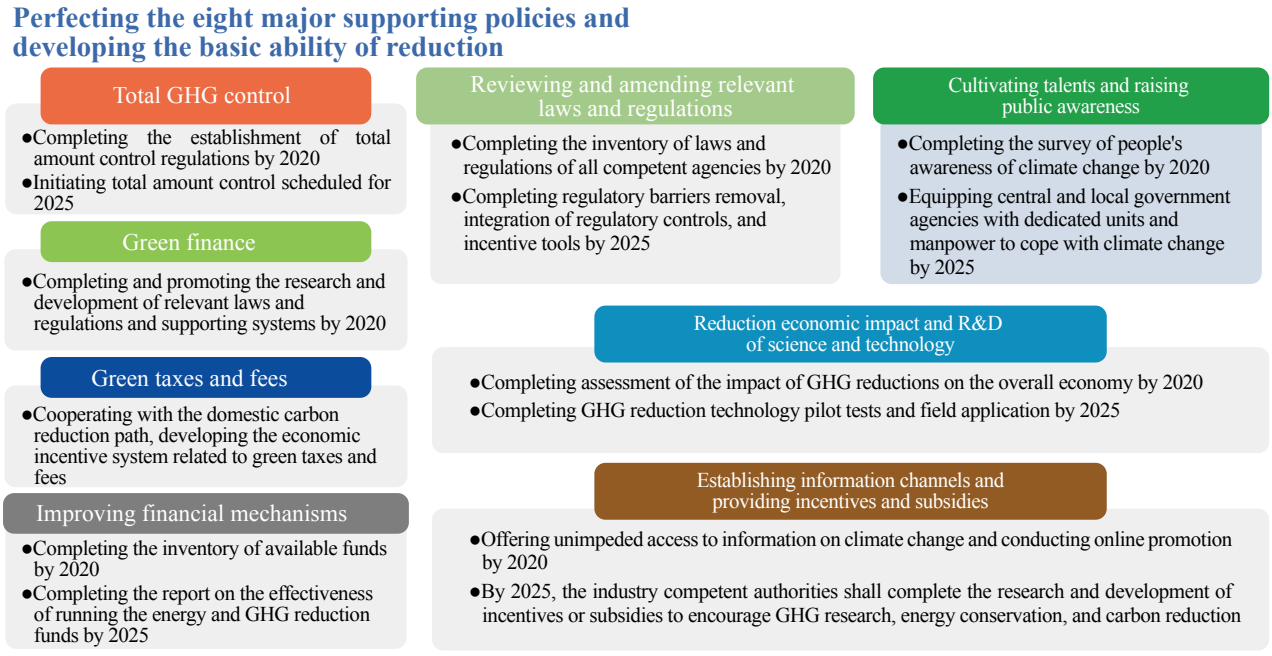


Figure 3.3.8 Eight supporting policies

Source: Executive Yuan EPA website on national regulations on GHG reduction.

3.3.3 Sector-based GHG Emission Control Action Programs

To achieve the goal of GHG control by phase, the GHG Emission Control Action Programs for the six sectors were drawn up and approved by the Executive Yuan on October 3, 2018. The specific implementation priorities of the sector-based programs are summarized as follows:

1. Energy sector

1) The energy sector's Action Programs are headed by the Ministry of Economic Affairs, which has developed 13 strategies and launched 42 projects. The main tasks include building a low-carbon energy supply system, initiating energy transition, swelling the proportion of renewable energy generation to 20% by 2025, substantially increasing the installed capacity of renewable energy generation like solar PV and wind power, boosting the unloading capacity of liquefied natural gas, raise the proportion of natural gas generation to 50% by 2025, and gradually reducing the use of coal and lower the proportion of coal-fired power generation to less than 30% by 2025.

2) A total of NTD 75.36 billion is expected to be invested from 2018 to 2020, with the projected benefits as follows:

   (1) The first phase is expected to reduce the CO_2eq by 6.316 million metric tons compared with 2015.

   (2) By 2020, the installed capacity of renewable energy generation will be increased to 10,875 MW, generating 25.2 billion kWh of electricity, which is estimated to reduce 4.195 million metric tons of CO_2eq compared with 2015.

   (3) By 2020, the unloading capacity of liquefied natural gas will rise to 16.5 million metric tons, and gas power generation will be increased and estimated to reduce the CO_2eq by 1.672 million metric tons compared with 2015.

   (4) Following the promotion of energy verification and voluntary reduction measures in the energy industry to improve energy conversion and utilization efficiency, it is estimated that 125,000 metric tons of CO_2eq will be reduced compared with 2015.

   (5) The power emission coefficient is expected to rise first and then drop. According to the energy supply allocation plan following energy transition, the power emission coefficient will fall from 0.529 (kg CO_2eq/kWh) in 2016 to 0.492 (kg CO_2eq/kWh) by 2020 and 0.376 (kg CO_2eq/kWh) by 2030.

2. Manufacturing sector

1) Under the leadership of the Ministry of Economic Affairs, the Action Programs for the manufacturing sector have mapped out 13 strategies and launched 30 measures, including the guidance of industry carbon reduction, industrial transformation, and sustainable production processes. Emphasis is placed on boosting energy efficiency of industrial processes and public facilities, introducing energy management systems, promoting industry inspection and counseling, and providing energy-saving technical advisory services to reduce GHG emission intensity.

2) A total of NTD 1.62 billion is expected to be invested between 2018 and 2020, with the following projected benefits outlined:

(1) Phase 1 is expected to reduce GHG emissions by 4 million metric tons of CO_2eq.

(2) Carbon intensity in the manufacturing sector is expected to decrease by 43% in 2020 on 2005.

(3) Investment will be boosted by NTD 25 billion.

3. Transportation sector

1) The Action Programs for the transportation sector are under the leadership of the Ministry of Transportation and Communications, which has planned three major strategies, including the development of public transit system, the strengthening of transport demand management, the construction of a green transport network, the promotion of low-carbon vehicles, the establishment of a green modes-oriented transport environment, and the enhancement of transport system and transport energy efficiency.

2) Priorities: Continuously boosting public transit volume (including highway public transport, railway, high-speed rail and MRT systems), which will grow at least 7% by 2020 compared with 2015; slowing down and reducing the use of private vehicles. In addition, in line with the policy of vehicle electrification announced by the Executive Yuan: "New vehicles on official duties and urban buses are electrified by 2030, new motorcycles by 2035, and new cars by 2040.," Supporting measures will be planned and launched for electric vehicles to reduce the use of vehicle fuel, cut GHG emissions, and help limit air pollution.

3) From 2018 to 2020, a total of NT$79.0478 billion is expected to be invested, and the total carbon reduction by various measures of the transportation sector's Action Programs is estimated to be 1.98 million metric tons of CO_2eq. The evaluation indicators are as follows:

(1) Highway public transport passenger capacity by 2020 is up 2% than that in 2015.

(2) Railway passenger capacity by 2020 is up 2% than that in 2015.

(3) High-speed rail passenger capacity reaches 63 million by 2020, up 24.6% from 2015.

(4) MRT passenger capacity reaches 903 million by 2020, up 16.1% from 2015.

(5) 121,000 electric motorcycles are traveling on the roads between 2018 and 2020.

4. Residential and commercial sectors

1) The Ministry of the Interior (MOI) is in charge of the Action Programs for the residential and commercial sectors (among which the Ministry of Economic Affairs is responsible for the commercial sector while the Ministry of the Interior is responsible for the residential sector). In the first stage, the control focus on the residential and commercial sectors aims to elevate the energy-saving design base value of the building shell of newly-built buildings, strengthen the management of existing buildings reduction, and plan and construct the carbon reduction capacity of the industry competent authorities in the service sector.

(1) Planning strategies and measures at the present stage: introducing green building regulations and labeling systems, managing energy efficiency of construction equipment, taking mandatory control measures in the service industry, launching guidance programs for specific persons or groups, promoting voluntary carbon reduction, incentives and subsidies in the service industry, among others. More than 7,000 green building policies have been promoted by the end of October 2018 (see Table 3.3.1). As the country with the highest density of green buildings in the world, they are an important foundation to promote sustainable development of the nation.

(2) Future improvements: enhancing the energy efficiency of newly-built buildings, managing the reduction of existing buildings, planning the transparency mechanism of energy consumption information on building shells, reinforcing the function of consultation over GHG emissions in the service sector, linking the synergy of local governments, and holding professional training courses, along with industrial associations.

2) The GHG emission control goals in the residential and commercial sectors are as follows:

(1) Upgrading the energy-saving design base value of the building shell of the newly-built building will increase by 10% by 2020 compared with that of 2016.

(2) The electricity efficiency of public sector buildings will improve 5% by 2020 and 10% by 2025, compared with that of 2015, reaching the announced Energy Usage Index (EUI).

Table 3.3.1 Statistics of green building labels and green building candidate certificates approved over the years

Year	Label	Candidate certificate	Sub-total
2000	1	4	5
2001	2	6	8
2002	2	116	118
2003	8	169	177
2004	17	256	273
2005	43	278	321
2006	76	230	306
2007	96	300	396
2008	96	253	349
2009	126	339	465
2010	116	215	331
2011	173	281	454
2012	209	272	481
2013	259	357	616

Note: as of the end of October 2018.

Source: Construction and Planning Agency of the Ministry of the Interior.

(3) By 2020, the transparency mechanism of energy consumption information on building shells will be completed and implemented.

3) It is estimated that the first phase of the residential and commercial sectors' Action Program (2016-2020) will achieve a reduction of 3.3282 million metric tons of CO_2eq. The expected budget for 2016-2020 is NTD 2.025 billion.

5. Agricultural sector

1) The Action Programs for the agricultural sector are headed by the Council of Agriculture of the Executive Yuan, which mainly deal with the acquisition and handling of fishing boats and rafts, incentives for suspension of fishing, promotion of organic and environmentally friendly tillage, promotion of green environmental payment to the land, popularization of biogas reuse (power generation) in livestock farms, maintenance and assurance of self-sufficiency of domestic livestock and poultry products, afforestation and strengthening forest management, among other measures.

2) The expected budget for 2018-2020 is NTD 32.527 billion. It is estimated that the total carbon reduction of the agricultural sector's Action Programs will reach 136.91 kt of CO_2eq by 2020, and the removal in the forestry sector will reach 42.59 kt of CO_2. Important policy goals in the agricultural sector are as outlined below:

(1) Increasing organic and friendly farming areas to 15,000 hectares by 2020 and 22,500 hectares by 2025.

(2) Guiding the reuse of biogas (power generation) in livestock farms, with the total head accounting for 50% of the total inventory by 2020 (estimated 2.5 million head) and for 75% by 2030 (estimated 3.75 million head).

(3) Increasing the area of afforestation to 3,636 hectares by 2020 and 7,176 hectares by 2025.

6. Environment sector

1) The environment sector's Action Programs are governed by the Environmental Protection Administration of the Executive Yuan. When planning policies and developing and implementing the environmental impact assessment (EIA), specific actions like resilience construction and emission mitigation should be taken into account. Energy resources recycling should be implemented and shared economy and society should be created to promote regional energy resources reuse. Moreover, GHG emissions from waste and sewage/wastewater treatment should be reduced.

2) Priorities: reducing the discharge of waste and sewage/wastewater during treatment, continuously rewarding biogas generation landfills for methane recovery and reuse, continuing the construction of sewerage systems, and improving the national sewage treatment rate by 2020 to 60.8%.

3) The required funds for 2018-2020 are estimated to be about NTD 52.287 billion (the ongoing construction of the sewerage system constitutes 97%). The expected benefits are as follows:

(1) Increasing the national sewage treatment rate to 60.8% by 2020.

(2) Enhancing methane recovery: recycling 0.15 $MtCO_2eq$ of methane from general waste landfills from 2018 to 2020.

(3) Energy resources recycling: implement material sustainable recycling and continue refining the waste reduction mechanism in order to turn waste to resources as a premise and lower the demand for final treatment of waste.

3.3.4 Local government GHG Control Implementation Plans

To enhance the ability of society to cope with climate change, the EPA has formed a long-term partnership with local governments to coordinate the implementation of climate change response plans, which are based on a low-carbon sustainable homeland and incorporate local characteristics and thinking into the strategies to promote carbon reduction and adaptation and to heighten public awareness of carbon reduction and social potential for carbon reduction.

The Greenhouse Gas Reduction and Management Act has defined the powers and responsibilities of government organs and different promotion strategies, and also incorporated the mechanism of participation from all walks of life and promotion by hierarchical responsibilities. According to Article 15 thereof, special municipality, county and city competent authorities shall develop GHG Control Implementation Plans in accordance with the Action Plan and the sector-based Action Program. 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 is based on Article 14 of the corresponding Enforcement Rules, including the objectives of the plan, the implementation timetables, implementation strategies, expected benefits and an evaluation mechanism. The framework of the Implementation Plans is shown in Figure 3.3.9.

Implementation plan framework	
Current situation analysis	• Environmental, social and economic situation, emission characteristics, promotion situation
Program objectives	• Setting qualitative or quantitative targets that can be achieved by 2020 with the promotion strategy
Promotion schedule	• Target schedule of the action plan and action program (2018-2020)
Promotion strategies (including organizers and co-organizers, and budgeting)	• Referring to the action plan and action program approved by the Executive Yuan, the cooperative matters between the central and local governments, and the local promotion policy formulation. The drafting principles are as follows: — According to local characteristics, developing strategies to suit local conditions — Focusing on livelihood issues, giving priority to promoting actions in residential, commercial and transportation sectors — Encouraging civil participation and expanding public-private partnership — Central government and local governments working together to implement them through local governance — Considering the feasibility of the strategy and the effectiveness of the cost, formulating the strategy implementation sequence Inter-bureau integration and promotion, clear division of labor among organizations
Expected benefit	• Proposing achievable vision or benefits
Evaluation system	• Special municipality, county and city governments shall develop management assessment mechanisms

Figure 3.3.9 Framework of the Implementation Plans

Source: Executive Yuan EPA website on national regulations on GHG reduction.

In the future, local governments will consult for the contents of the Action Plan and the Action Programs, while taking into account the characteristics of local governance and planning the Implementation Plans to facilitate the link and correspondence between the Action Plan, the Action Programs, and the local Implementation Plans, thereby gaining synergy between local governments and civic groups and jointly strengthening GHG reduction work.

3.4 Relevant laws and supporting policies

3.4.1 Energy Administration Act

Since its promulgation in 1980, the Energy Administration Act has undergone five amendments, the last amendment date being November 30, 2016. In response to the amendment and the promulgation of the Electricity Act on January 26, 2017, where the electric utility is divided into electric power generation, transmission and distribution, and retailing, the applicability of this law shall be amended accordingly as it involves the provisions of the Electricity Act. Meanwhile, in order to expand energy administration and strengthen energy conservation measures, the Ministry of Economic Affairs has drawn the draft amendments to some provisions of the Energy Administration Act and submitted them to the Executive Yuan for approval before they were passed on to the Legislative Yuan for deliberation.

Article 1, Paragraph 2 of the Energy Administration Act stipulates that the Ministry of Economic Affairs shall draft the Energy Development Guidelines as the guiding principle of the national energy policy. In line with the energy transition policy, the Ministry of Economic Affairs in 2016 proposed the Energy Development Guidelines (draft amendment), which were revised by the Executive Yuan on April 24, 2017, to establish Taiwan's energy transition and the development framework with the ultimate goal of a nuclear-free homeland by year 2025.

Mainly focusing on "energy security," "green economy," "environmental sustainability," and "social equity," the Energy Development Guidelines set out the necessary guidelines and supporting regulations for achieving the national energy development goals, in order to comprehensively promote the energy transition policy, including energy conservation, energy creation, energy storage, and intelligent system integration. Meanwhile the gradual reduction of the proportion of nuclear power generation will attain the goal of a nuclear-free homeland by 2025. The framework of the Energy Development Guidelines is exhibited in Figure 3.4.1.

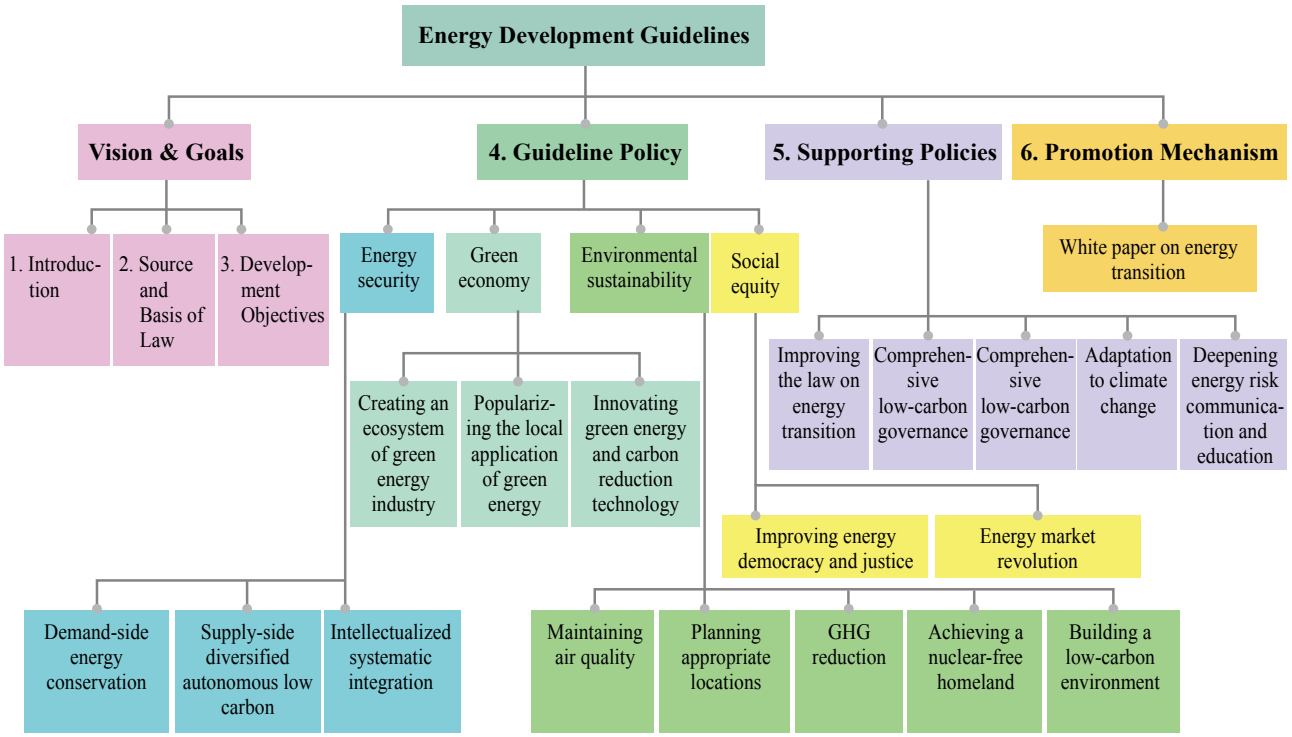


Figure 3.4.1 Framework of the Energy Development Guidelines

Source: Executive Yuan EPA website on national regulations on GHG reduction.

3.4.2 Electricity Act

To gradually implement the vision of a nuclear-free homeland under the Basic Environment Act, the long-term national goal of reducing GHG under the Greenhouse Gas Reduction and Management Act, promote the national energy transition and develop green energy, the government promulgated a new version of the Electricity Act in January 2017. In the first stage, green power liberalization and public power grids are being advocated before the second revision of the law, pending the maturity of the relevant operation and mechanism for the purpose of power industry deregulation. By doing so, that the Act intends to the goal of "supply diversification, fair use and free choice," under the premise of stable power supply.

Given that the electricity retailing utility enterprise can influence the power generation ratio by purchasing different fuels for electricity, the new Electricity Act regulates the enterprises and stipulates the sale of electricity to conform with the electricity carbon emission factor benchmark established by the government. In an attempt to cut emissions, those failing to comply will face fines and required rectification within a specified period of time.

Moreover, to encourage the installation of renewable energy systems in the power generation end, the renewable-energy-based electricity generating enterprise may obtain the discount of electricity dispatching service fees and electric power wheeling fees to reduce its power generation costs. For traditional power plants, if their annual net profit exceeds a certain proportion of the total paid-in capital, a considerable amount should be allocated for the purpose of strengthening the operation and maintenance of units, investing in

equipment for cutting pollution emissions and developing renewable energy.

3.4.3 Renewable Energy Development Act

For purposes of encouraging renewable energy use, the Renewable Energy Development Act was promulgated in 2009 to promote energy diversification, improve environmental quality, assist relevant industries and enhance sustainable development of the country. Through the renewable energy fit in tariffs (FIT) to guarantee parallel connection and the purchase of renewable energy power, along with supporting measures such as demonstration incentives and relaxation of the rules, the nation provides investment incentives for installing renewable energy systems to spur the development of renewable energy.

In January 2018, the Executive Yuan submitted to the Legislative Yuan the draft amendment to the Act for deliberation, which was revised based on three aspects of "multiple utilization," "simplified procedure," and "widening participation." The amendments intend to optimize the environment for renewable energy development in Taiwan, enhance the efficiency of policy promotion and the goal of renewable energy popularization be gradually ensuring diversified green power purchase and sale modes, simplifying the application procedures for renewable energy generation equipment, and requiring big consumers to install a certain proportion of renewable energy generation equipment to fulfill their corporate social responsibility.

3.4.4 Green tax system

As both the Action Guideline and the Action Plan contain supporting policy on the green tax system, the feasibility of levying energy tax or imposing GHG management fees by amending the Greenhouse Gas Reduction and Management Act is being discussed.

To cushion the impact on people's livelihood and industry, the energy tax is scheduled to be levied on a specific basis, with the tax amount to be adjusted step by step, while some items of commodity tax are suspended. In compliance, such taxation is hoped to stimulate people to save energy and improve the efficiency of energy use, and promote the development of energy-saving industries, thereby boosting economic growth. In addition, it will help to curb CO_2 emissions and fulfill the nation's obligations as a member of the international community.

The GHG management fee to be levied aims at large emission sources beyond total emission control. On the premise of not repeating the levy, it plans the GHG management fee in order to increase the control tools and methods for GHG reduction. In the initial stage, the list of sector-based objects to be checked and registered will be expanded. Following the compulsory inventory, a levy on the sources of emissions will be imposed directly, and the levied fees will be included in the sources of income of the GHG management fund, which will be used for GHG reduction and climate change adaption.

3.4.5 Green Finance Action Plan

To follow the international development trend towards green finance and pursue national policies such as a nuclear-free homeland, energy transition, and emission reduction, the Executive Yuan in November 2017 approved the "Green Finance Action Plan" proposed by the Financial Supervisory Commission (FSC), which covers seven aspects: credit extension, investment, capital market financing, talent cultivation, promotion of the development of green financial products or services, information disclosure,

and promotion of the ideal of green sustainability. The plan consists of 25 measures jointly implemented by government agencies such as the FSC, the Ministry of Economic Affairs (MOEA), the Ministry of Finance (MOF), the National Development Council (NDC), the Environmental Protection Administration (EPA), and the National Development Fund, with the aim of injecting financial resources into green industry and green consumption, and creating a win-win situation for finance, industrial entity, and society.

The Green Finance Action Plan includes: encouraging domestic banks to extend credit to the green energy industry, encouraging banks to voluntarily adopt the Equator Principles, loosening bank credit and financing norms; developing Taiwan's green bond market, guiding responsible investment in the capital market; motivating insurance funds to invest in the green energy industry, loosening indirect investment in green energy industry by insurance funds, relaxing the restrictions on other funds through the investment channels of private equity funds, venture capital, and venture capital management for domestic public construction and green energy industry, strengthening the cultivation of green financial talents, spurring financial institutions to participate in the monthly "meeting of the third-party testing, verification, and communication platform for renewable energy investment (financing)" convened by the MOEA Bureau of Standards, Metrology and Inspection, among other important green finance measures. Taiwan has set up green financial systems and guidelines to push various measures of green finance from the aspects of credit, investment, financing and talent cultivation, to promote the development of real economy and green consumption and to help enhance the competitiveness of the financial industry. In the future, green finance will continue to be updated and promoted in a continuous and rolling way, in order to support the development of green energy industry with finance and drive the development of green finance with green economy.

3.4.6 Three national land management laws

1. Spatial Planning Act

To cope with climate change, assure land use security, conserve the natural environment and cultural assets, promote the reasonable allocation of resources and industries, strengthen land consolidation and management mechanisms, and restore sensitive areas and damaged land in pursuit sustainable development, the government had actively enacted the Spatial Planning Act, which was promulgated in January 2016 and enforced in May 2016 to bring the sustainable development of the land into a new milestone.

The key contents of the Act include: establishing the spatial planning system, confirming the priority of spatial planning, demarcating the land into functional zones, setting up the licensing system, building the information disclosure mechanism, incorporating the people into supervision, promoting environmental restoration, fostering environmental sustainability, safeguarding the existing rights of the people, and formulating the compensation and relief mechanism.

2. Coastal Zone Management Act

Taiwan is surrounded on all sides by the sea, with a coastline of approximately 1,578 km long and a large area of coastal land. In recent years, with the rapid growth of society, economy and population, coastal zones have become indispensable in the nation's territorial development. However, land use in coastal areas has comprehensiveness and irreversibility. To maintain natural coastal resources, the conservation, protection and development of coastal areas should be put into perspective from comprehensive viewpoints

in a bid to give consideration to the harmony of the three.

To maintain natural systems, the Coastal Zone Management Act was promulgated in February 2015 to ensure zero loss of the natural coast, respond to climate change, prevent coastal disasters and damage to the environment, protect and restore coastal resources, implement integrated coastal zone management and promote the sustainable development of coastal zones,. Guiding principles for the overall utilization of coastal areas were laid down through the integrated coastal zone management plan, which guides and integrates the management of coastal areas and designates the location of coastal conservation and protection, as well as the organs making plans and deadlines. Subsequently, according to the "Coastal Conservation Plan" and "Coastal Protection Plan," the government is required to actively protect natural resources and prevent disasters, guide the building of a review and licensing mechanism for the development and construction of coastal zones and further control the exclusive use of coastal waters and the construction of man-made facilities, so as to ensure public access and use.

3. Wetland Conservation Act

To ensure the natural flood control and related functions of wetlands to maintain biodiversity, and promote wetland ecological conservation and wise use, in addition to ensuring a no net loss of important wetlands and strengthening the interaction between wetlands and communities, the Wetland Conservation Act was promulgated in July 2013 and came into force in February 2015.

Based on the idea of "wise use," the Act formulates conservation and utilization plans for substantive management according to local conditions as important wetlands are scattered throughout the country and respects the people's ever-present use.

3.5 Reduction policy planning in accord with the Paris Agreement

Despite the exclusion from the UNFCCC, Taiwan, as a member of the global community, has been quietly striving to fulfill its role as a global citizen for a long time and has been doing its utmost to respond to the propositions and activities of the UNFCCC with practical actions. The Greenhouse Gas Reduction and Management Act established GHG regulatory goals in stages on a five-year basis. In addition to referring to the existing Intended National Determined Contribution (INDC), it consults the Paris Agreement and carries out the Nationally Determined Contribution (NDC) management strategy, so that the nation can fulfil the objectives set out in the NDC under the Act and link them with the regulations and strategies of the UNFCCC.

Taiwan's long-term GHG reduction target by 2050 can also correspond with that in the Paris Agreement, which aims to control the rising range of the Earth's temperature within 2 degrees Celsius as compared with the pre-industrial era, and attempts to limit the foregoing range within 1.5 degrees Celsius. In the years to come, the nation will continue to keep abreast of the latest progress of the Paris Agreement, as well as to formulate relevant sub-acts and supporting measures under the Act and promote relevant work in response to climate change, gradually complete the construction of domestic laws and regulations, and regularly review the GHG reduction targets, thus laying a solid foundation for Taiwan to move towards a low-carbon sustainable homeland.

Reference

1. Executive Yuan, Guidelines for the Establishment of the Executive Yuan Energy and Carbon Reduction Office, 2016.
2. Executive Yuan Energy and Carbon Reduction Office website.
3. Executive Yuan Energy and Carbon Reduction Office, National Green Finance Action Plan approved (Nov. 2017) .
4. Executive Yuan EPA, website on national regulations on GHG reduction: http://estc10.estc.tw/ghgrule/
5. MOEA, Action Program on GHG Emissions Control in the Energy Sector, 2017.
6. MOEA, Action Program on GHG Emissions Control in the Manufacturing Sector, 2017.
7. MOTC, Action Program on GHG Emissions Control in the Transportation Sector, 2017.
8. MOI, Action Program on GHG Emissions Control in the Residential and Commercial Sector, 2017.
9. Executive Yuan COA, Action Program on GHG Emissions Control in the Agricultural Sector, 2017.
10. Executive Yuan EPA, Action Program on GHG Emissions Control in the Environment Sector, 2017.

▲The Coastal Range National Scenic Area

Chapter 4
Greenhouse Gas Emission Forecast

Chapter 4
Greenhouse Gas Emission Forecast

Taiwan has set long-term objectives for GHG reduction and regulatory goals in stages on a five-year basis accordingly with the Greenhouse Gas Reduction and Management Act for the gradual realization and promotion of reduction policy. Based on the allocation of reduction targets among sectors and national reduction path planning, the sectors predict GHG emissions from 2017 to 2030 through hypothetical scenarios and model tools. This chapter explains Taiwan's GHG emissions projections on the basis of forecasting tools and the scope, benchmark situational analysis and trend estimation.

4.1 Forecasting tools and the scope

The following section describes the sectoral hypothetical situational parameters and model tools for GHG emissions from fuel burning and non-fuel combustion, as well as forest carbon sinks (i.e. removals in Chapter 2):

1. GHG emissions from fuel combustion

More than 90% of Taiwan's GHG emissions come from fuel burning. In 1993, the MARKAL energy engineering model made by the International Energy Agency (IEA) was introduced by the MOEA to Taiwan, and in 2010, was converted to the Taiwan Integrated MARKAL-EFOM System (TIMES) model. Through the detailed and flexible operation function of the model, the model has been applied to the evaluation of many significant domestic energy policies and decisions. Recent important assessments include the emission path of CO_2 from fuel combustion and the nation’s coal reduction path, which are the regulatory goals in stages, as prescribed in the Greenhouse Gas Reduction and Management Act. The TIMES model is a linear planning model, which is composed of huge and complex energy technologies stacked from bottom to top, and driven by the demand for energy services (exogenous variables). Considering the development situation of the energy system and with the goal of minimizing the cost of the energy system, a solution can be worked out, with the balance of energy supply and demand, environment and resource constraints.

To explore into the interaction between energy policy and economic and environmental fonts in a more comprehensive way, the Taiwan Integrated Sustainability Model (TISMO), developed by the TIMES model team of the MOEA Energy Bureau, with energy, economic and environmental integration, is based on the TIMES model in Taiwan to build the TISMO-CGE macroeconomic model and the TISMO-ENV environmental impact assessment module. The integrated evaluation function of the TIMES model is continuously expanded through soft links, with multifaceted evaluation information offered as a reference for decision-making. The integrated model architecture is shown in Figure 4.1.1 The energy sector brings in the social and economic parameters (population, GDP and tertiary industrial structure) provided by the National Development Council and the energy consumption and energy conservation provided from various sectors into the integrated model to predict GHG emissions from fuel combustion between 2017 and 2030.

2. GHG emissions from non-fuel combustion

1) Industrial sector

The projection of GHG emissions from non-fuel combustion in the industrial processes and

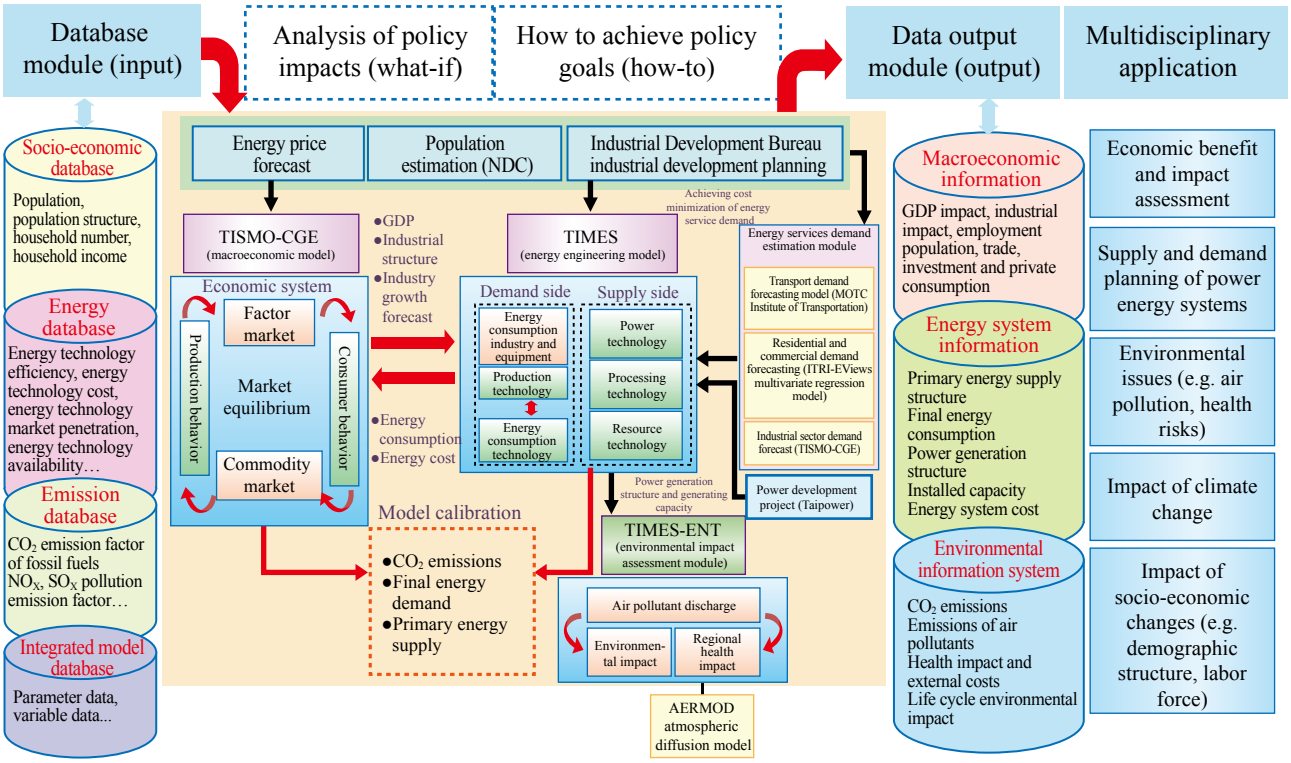


Figure 4.1.1 TISMO integrated model architecture for the energy sector

Source: Industrial Technology Research Institute, About TIMES Energy Engineering Model, What You Want to Know about—Introduction to Taiwan TIMES Energy Engineering Model, Understanding Energy BLOG.

product use sector, based on the statistical framework recommended by the IPCC 2006 Guidelines, is estimated from historical values and future development trends. After consolidating different industry and statistical items, the estimation method is described as follows:

(1) The emission of fluorine gas from the information of the electronics industry is estimated on the basis of historical values, industrial growth forecasts by the NDC, business investment and reduction planning.

(2) GHG emissions from basic iron and steel industry, basic non-ferrous metal industry, chemical material manufacturing industry, cement and cement product industry, glass and glass product manufacturing industry are estimated through econometric models based on historical trends, industrial growth prediction by the NDC and industrial policy objectives.

(3) GHG emissions from the use of alternatives to ozone-depleting substances, such as refrigerants for refrigeration and air-conditioning equipment, are estimated at an average annual growth rate of 2.8% over the past three years (2013-2015).

2) Agricultural sector

Estimation methods for GHG emissions in the agricultural sector are mainly based on models jointly developed by the Center for Sustainability 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 on the basis of computable general equilibrium (CGE) is used to predict the trend of GHG emissions with a top-down approach. Additionally, the Taiwan Agricultural Sectoral Model (TASM) and the Taiwan Fishery Sectoral Model (TFSM) are applied to perform bottom-up detailed calibration, while further consideration is given to future socio-economic development trends, energy price growth and other parameters. In the process, expert symposia are held to collect practical experience and opinions of experts to make detailed corrections. The modules are shown in Figures 4.1.2 and 4.1.3.

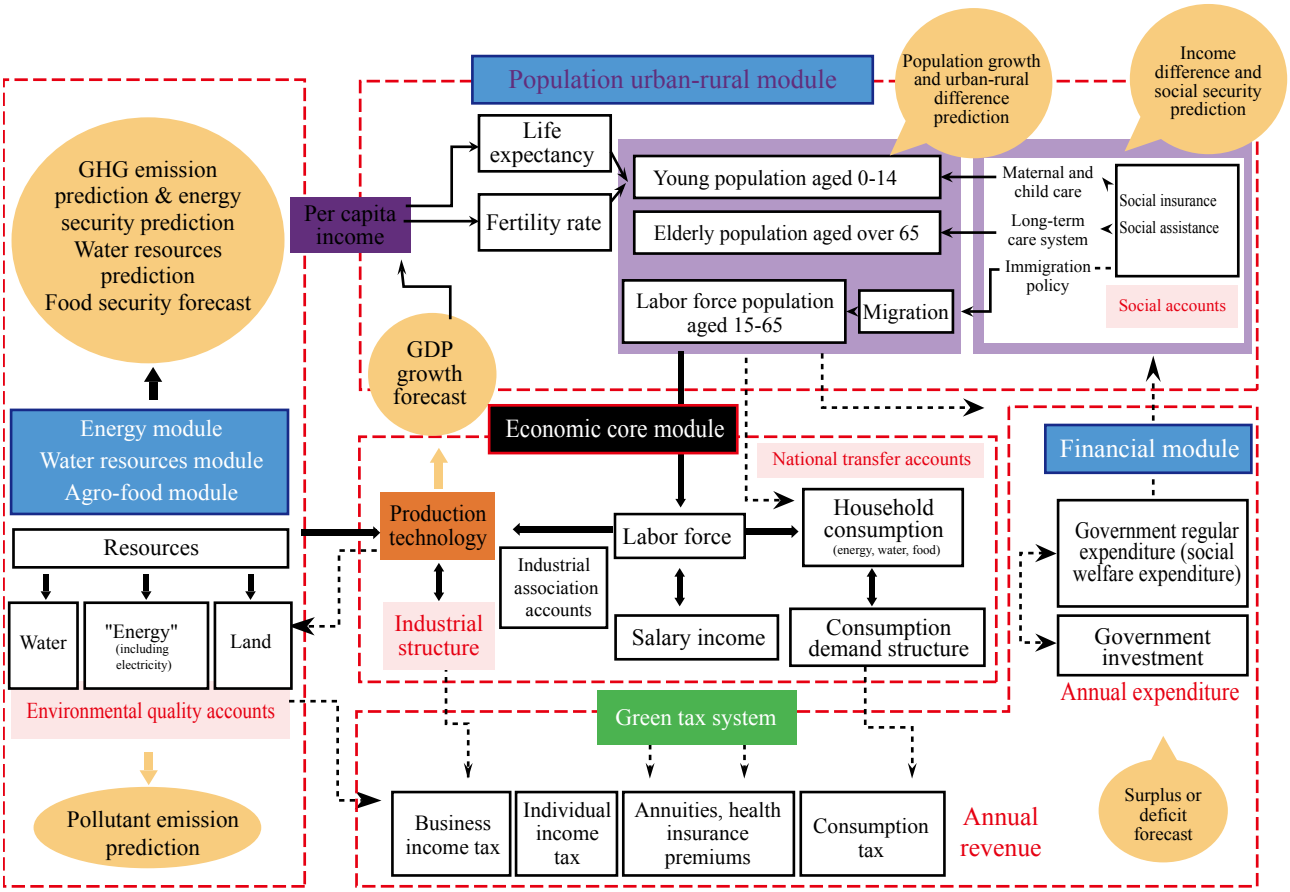


Figure 4.1.2 GEMTEE policy analysis module for the agricultural sector

Source: Executive Yuan COA (2017), Estimation of GHG Emissions Trend from Non-fuel Burning in the Agricultural Sector of Taiwan.

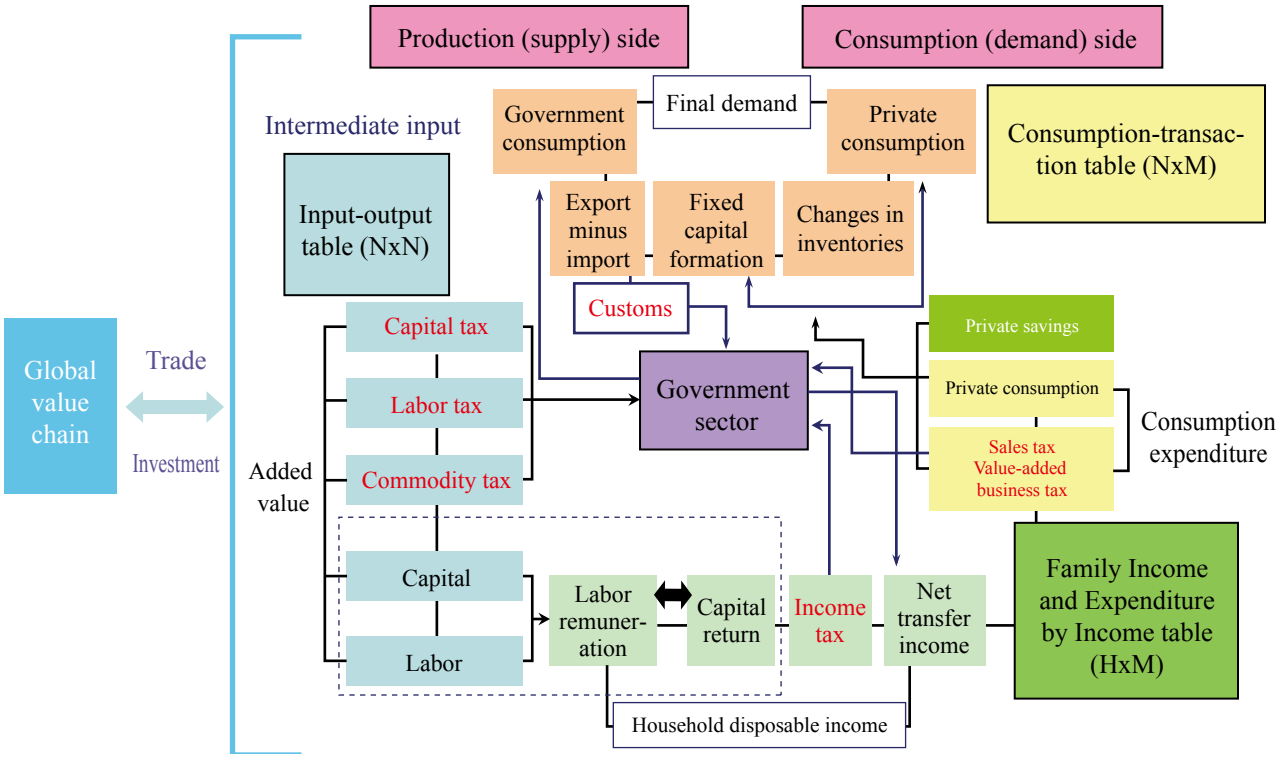


Figure 4.1.3 GEMTEE database architecture for the agricultural sector

Source: Executive Yuan COA (2017), Estimation of GHG Emissions Trend from Non-fuel Burning in the Agricultural Sector of Taiwan.

Based on the above principles, the estimation approaches to emissions from various sources are as follows:

(1) Burial disposal emissions: The sanitary landfill volume is estimated from that of 2006 to 2015 by power type function, the methane recovery amount is estimated from that of 2007 to 2015 by exponential type function, and the general landfill volume is estimated from the average one of nearly eight years from 2008 to 2015.

(2) Domestic sewage discharge: the sewage treatment rate is the estimate from 2017 to 2020 by the Construction and Planning Agency of the Ministry of the Interior; the population is estimated by extrapolation from the population; the annual treatment capacity of the national sewage plant is estimated by the linear function of the treatment capacity from 2009 to 2015, and the daily protein supply per person is estimated by the average value of nearly 12 years, from 2004 to 2015.

(3) Composting: estimated by the trend line of nearly five years, from 2011 to 2015.

(4) Incineration: estimated by the average of nearly five years, from 2011 to 2015.

(5) Industrial wastewater: chemical oxygen demand (COD) is estimated by the average of nearly nine years, from 2007 to 2015, and total nitrogen (TN) emissions are estimated by the average of nearly three years, from 2013 to 2015.

3) Forestry sector

(1) Carbon sink trend estimation method

A forest carbon sink is mainly the sum of "woodland maintained as woodland" and "other lands converted to woodland." The carbon sequestration of "woodland maintained as woodland" accounts for more than 90% of the total forest. Over the past 20 years, forest carbon sinks have remained stable due to the implementation of laws and policies such as the Regional Plan Act, the Forestry Act and the ban on deforestation. Assuming that there is no significant change in afforestation policy in the future, the average area of each forest type in the past 10 years in the forest resource survey is used as the basis for future estimation, while the carbon sink loss caused by forest fires, illegal logging and deforestation is based on the average of the past three years for future estimation. The "Other lands converted to woodland" item is the result of previous years' afforestation, and 20 years after the expiration, included in the area of woodland maintained as woodland.

(2) Carbon sink estimation scenario setting

Carbon sinks mainly come from "woodland maintained as woodland" and are influenced by policies. Under the assumption that the future policy remains unchanged, variations in carbon sinks mainly stem from the loss of carbon sink due to a landslide. Therefore, the situations of "not considering a landslide" and "considering a landslide" are divided into "high case" and "low case" to estimate the trend of forest carbon sinks.

(a) Scenario 1 "High Case": This scenario assumes that the government can take preventive measures against the collapse-prone areas in Taiwan so that no landslide in the woodlands will occur in the future. Therefore, scenario 1 assumes that there will be no landslide in the woodlands in the future and the average area of each forest type of "woodland maintained as woodland" is the average of the last 10 years.

(b) Scenario 2, "Low Case": "Woodland maintained as woodland" considers the collapse situation every year. The average collapse area of each forest type is assumed to be that of the last 3 years, and the vegetation will be restored after 10 years.

4.2 BAU analysis

To run the models of various sectors for simulation in a consistent business-as-usual (BAU) scenario, hypothetical conditions are proposed for the main indicators such as major macroeconomics, population and energy. The scenarios of the indicators are described below.

1. Gross Domestic Product (GDP)

Taking into account the situation at home and abroad, including the population trend, international energy price, international economic and trade environment and the total factor productivity, as well as the industry development trend and policy direction provided by various industry competent authorities, Taiwan's medium and long-term GDP and the proportion of the tertiary industrial structure are estimated as one of the hypothetical conditions of the BAU. In 2017, the overall economic growth rate was 2.89%, where the service industry accounted for 62.87% of GDP in the tertiary industrial structure, followed by industry for 35.40% and agriculture for only 1.72%.

2. Population projections

The cohort-component method, which is commonly adopted in the world, is used to forecast the population of Taiwan. Based on the household population of the single-year age groups of males and females as the end of 2017, the assumptions of birth, death and international net migration, including the moving-in and moving-out registration of nationals and foreigners were factored in to estimate the future single-year age population of men and women, by increasing each person's age year by year.

According to the "Population Estimation of Taiwan (2018-2065)" report issued by the NDC on August 30, 2018, the total population of Taiwan will reach a peak of 23.61 million by 2021. In the three different scenarios of low, medium and high estimates, the total population will fall to 16.61 million to 18.8 million by 2065, which is about 20-30% less than in 2018.

3. Energy transition policy

To attain the goal of a nuclear-free homeland by 2025 and to credit carbon reduction commitments to the international community, and in response to the rapid changes and challenges in the domestic and international political and economic situations and energy environment, Taiwan has adopted its energy transition policy for gas, coal and renewable energy to make up 50%, 30% and 20% of the total power supply

respectively by 2025, and for nuclear power units to be completely decommissioned in May of the same year. The decommissioning time is shown in Table 4.2.1.

Targets for the unloading capacity of imported natural gas are set out in Table 4.2.2: 3,270 tons by 2025 to 3,590 tons by 2030; gas generation from 32% in 2016 to 36% by 2020 and to 49% by 2025. The proportion of coal-fired power generation increased from 45% in 2016 to 46% in 2017, down to 43% by 2020 and 29% by 2025. The installed capacity of renewable energy aims at 30,066 MW by 2030, accounting for 5% of electricity generation in 2016, projected to rise to 9% by 2020 and 20% by 2025 (Tables 4.2.2 to 4.2.4).

Table 4.2.1 Decommissioning times of nuclear power plants

Unit	Decommissioning times
First Nuclear Power Plant Unit 1	5th December 2018
First Nuclear Power Plant Unit 2	15th July 2019
Second Nuclear Power Plant Unit 1	27th December 2021
Second Nuclear Power Plant Unit 2	14th March 2023
Third Nuclear Power Plant Unit 1	26th July 2024
Third Nuclear Power Plant Unit 2	17th May 2025

Source: Atomic Energy Council (AEC)

Table 4.2.2 Natural gas capacity planning

Unit: Ten thousand tons

Item \ Year	2020	2025	2030
Unloading capacity	1,650	3,270	3,590

Source: MOEA Bureau of Energy.

Table 4.2.3 Renewable energy installed capacity

Unit: MW

Item \ Year	2020	2025	2030
PV	6,500	20,000	20,000
Onshore wind power	814	1,200	1,200
Offshore wind power	520	3,000	5,500
Geothermal energy	150	200	250
Biomass energy	768	813	855
Water power	2,100	2,150	2,200
Hydrogen energy and fuel cells	22.5	60	60
Total	10.875	27,424	30,066

Source: MOEA Bureau of Energy.

Table 4.2.4 Renewable energy generation

Unit: 100 million kWh

Item \ Year	2020	2025	2030
PV	81	256	256
Onshore wind power	20	29	29
Offshore wind power	19	118	217
Geothermal energy	10	13	16
Biomass energy	56	59	63
Water power	64	66	68
Hydrogen energy and fuel cells	2	5	5
Total	252	546	654

Source: MOEA Bureau of Energy

4.3 Trend estimation

To work out GHG phase control objectives, the ministries estimate energy consumption and plan energy-saving and carbon reduction strategies based on socio-economic parameters. The MOEA energy bureau collects and estimates energy-related parameters and fuel combustion emissions. Ministries estimate the non-fuel combustion emissions from the sectors based on the socio-economic parameters and policy and measures. The Executive Yuan COA is responsible for carbon sink estimation, which is eventually compiled by the EPA. Estimation of GHG emissions is shown in Figure 4.3.1.

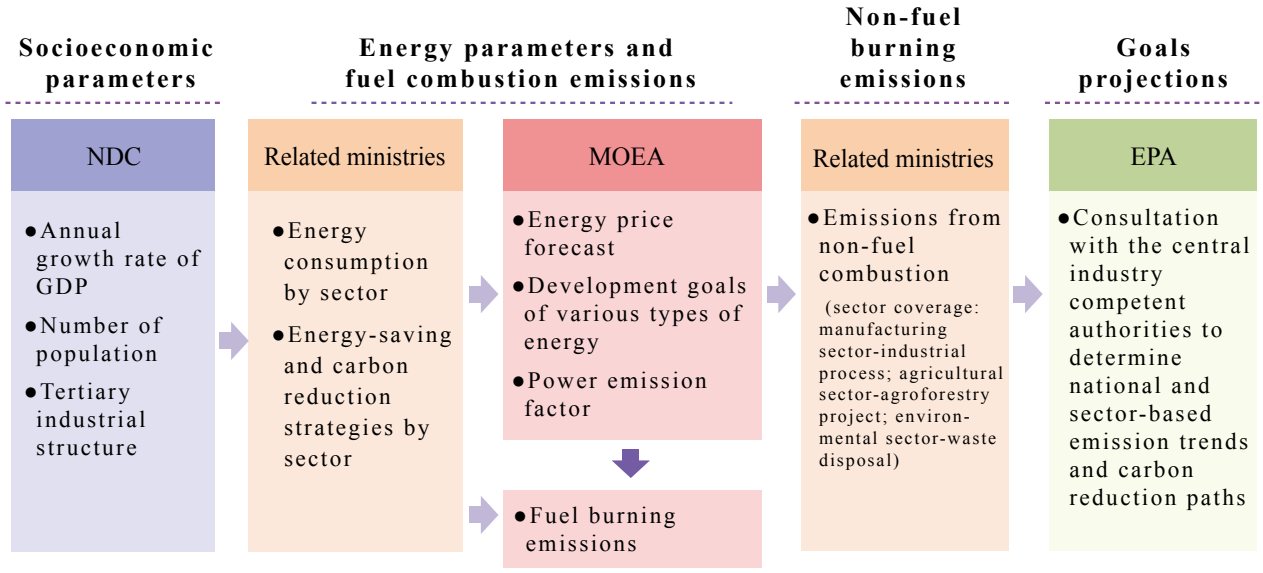


Figure 4.3.1 Projection of GHG emissions

Source: Executive Yuan EPA, Phase I Greenhouse Gases Regulatory Goals in Stages.

Taiwan's pathway of reducing carbon emissions has slowed down before even taking off. It is estimated that the GHG emissions in 2020 will decrease by 2% compared with the base year of 2005, that is to say, the nation's total net GHG emissions will fall to 260.717 million Mt CO_2eq by 2020, and 10% down by 2025 compared with the base year and 20% down by 2030 compared with the base year. Trends in GHG and carbon sink emissions are described below.

1. Trends in GHG emissions from fuel burning

Due to the increasing proportion of industry in the industrial structure (even if the proportion of energy-intensive industries will decrease), the share of agriculture and service industries will fall slightly. Additionally, ministries have adopted energy-saving and carbon-reducing measures, such as implementing the aforementioned new energy policy to lower the power emission coefficient, reducing energy intensity, enhancing the design benchmark value of the shell of newly-built buildings, improving the electricity efficiency of public sector buildings, and expanding public transport systems, forcing up sales volumes of electric vehicles, building green mode-oriented transportation environment, boosting energy efficiency of transport systems and vehicles, and fishing season off. The average annual growth rate of energy consumption and electricity consumption has been greatly reduced compared with the past. GHG emissions from fuel combustion peaked from 2017 to 2018, up 1.7% in 2020 compared with 2005 and down 7.9% in 2030. In addition to the annual rise in the transport sector, each sector reached its peak in 2017. Energy (self-use) and transport sectors' emissions in 2020 will be higher than those in 2015. On the whole, GHG emissions from fuel combustion are expected to emit 250 million tons of CO_2 by 2020, 228 million tons by 2025 and 226 million tons by 2030, as shown in Figure 4.3.2.

2. Trends in GHG emissions from non-fuel burning

Taiwan's non-fuel combustion GHG emissions peaked in 2004. Compared with the base year in 2005, the non-fuel combustion GHG emissions in 2016 were down 29.23% (without carbon sinks). In the manufacturing sector, the estimated emissions from basic non-ferrous metal industries and chemical industries remain unchanged, while those from cement production, glass production, iron and steel production, electronics industry, reduced use of alternatives to ozone-depleting substances and power equipment have increased year by year by 2030, although those from the agricultural and environment sectors have shown a downward trend with each passing year. Overall, the estimated GHG emissions from non-fuel burning by 2030 continue to show a slight upward trend year after year.

In terms of forestry carbon sinks, the area of landslide in the woodlands in the future will not continue to increase as described above, and the area of each type of woodland maintained as woodland is the average of the past 10 years. It is expected that the estimated absorption volume will show a flat trend in the future, as exhibited in Table 4.3.1.

The overall trend in GHG emissions from non-fuel burning shows a slight growth, 26.57% reduction in 2020 from 2005 and 24.31% decrease in 2030. Estimated non-fuel burning GHG emissions without carbon sinks in 2030 will be approximately 30,430 kt of CO_2eq (including reduction scenario in the electronics industry), plus 21,357 kt of CO_2eq of carbon sinks and 9,073 kt of CO_2eq of net emissions. The predicted trend in GHG emissions from non-fuel combustion is shown in Figure 4.3.3.

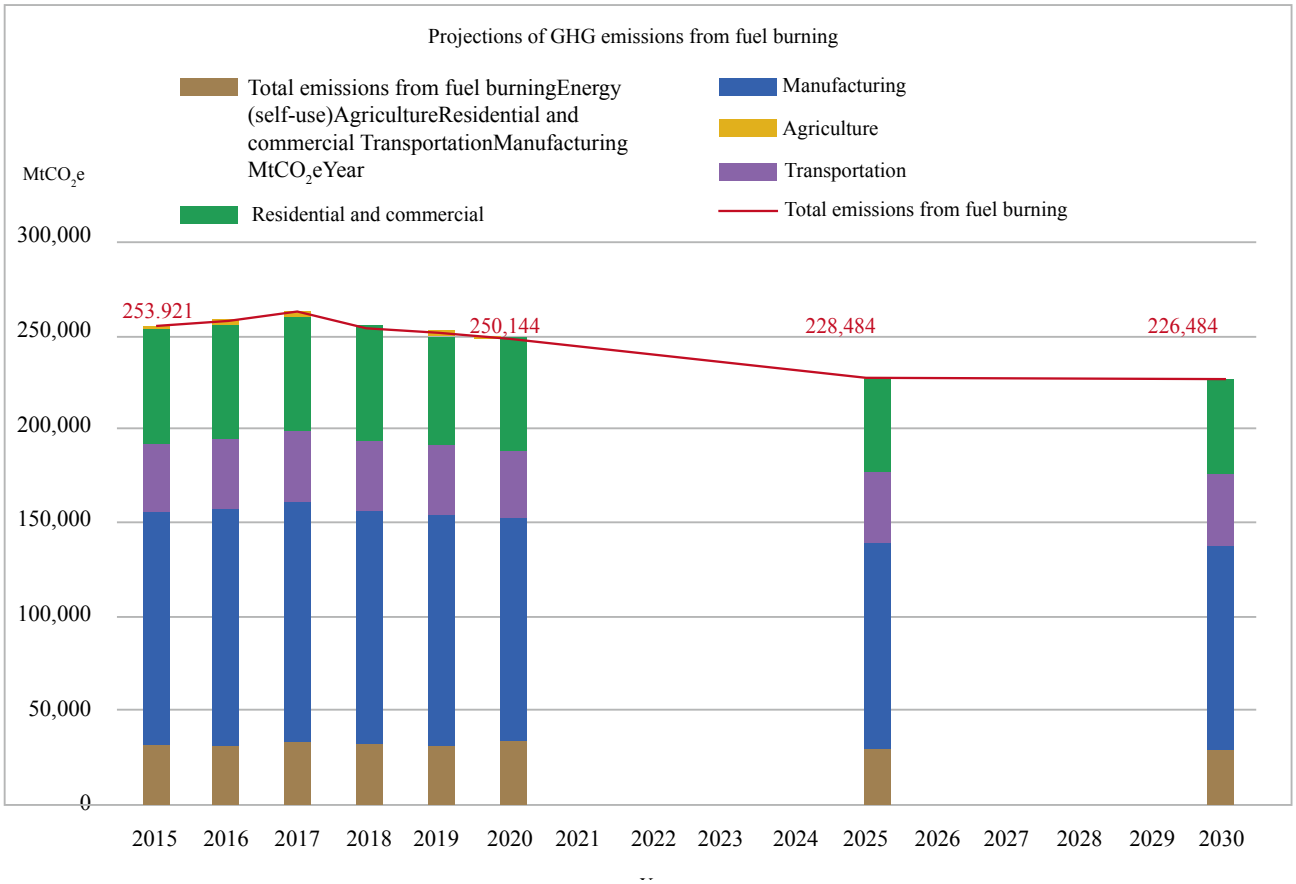


Figure 4.3.2 Projections of GHG emissions from fuel burning

Source: Executive Yuan EPA, Phase I Greenhouse Gases Regulatory Goals in Stages.

Table 4.3.1 Forestry carbon sink estimation

Unit: kt of CO_2 eq.

Year	Existing forest carbon sinks		Future carbon sink action plan		Total
	Woodland maintained as woodland	Other lands converted to woodland	Afforestation	Strengthening forest management	
2020	-20,830	-806	-30.96	-20.86	-21,687
2025	-21,106	-393	-61.11	-49.61	-21,610
2030	-21,173	-275	-91.26	-78.42	-21,618

Source: Executive Yuan EPA, Phase I Greenhouse Gases Regulatory Goals in Stages.

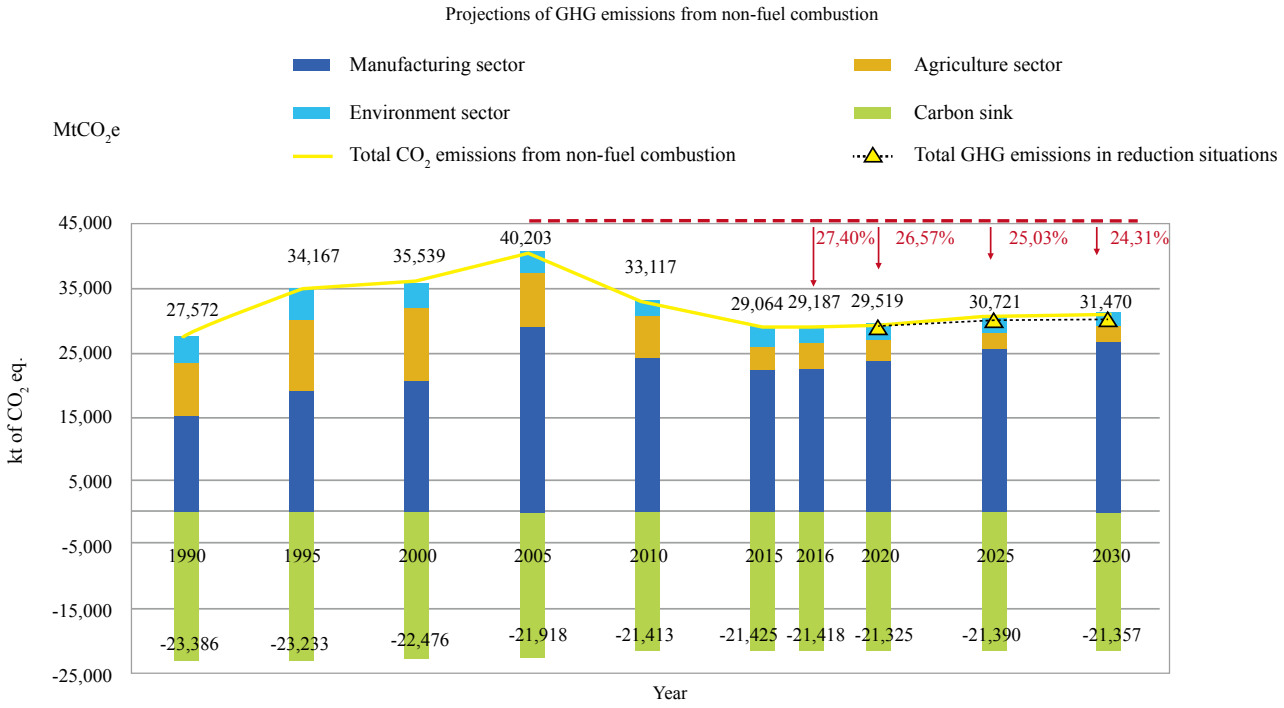


Figure 4.3.3 Projections of GHG emissions from non-fuel combustion

Source: Executive Yuan EPA, Phase I Greenhouse Gases Regulatory Goals in Stages.

3. Estimation of total GHG emissions

The estimation of total GHG emissions, including the estimated emissions from fuel combustion and non-fuel combustion, shows that the net emissions in 2020 will be 2.09% lower than the base year 2005, around 9.88% lower in 2025, and 10.06% lower in 2030 than the base year, as shown in Figure 4.3.4.

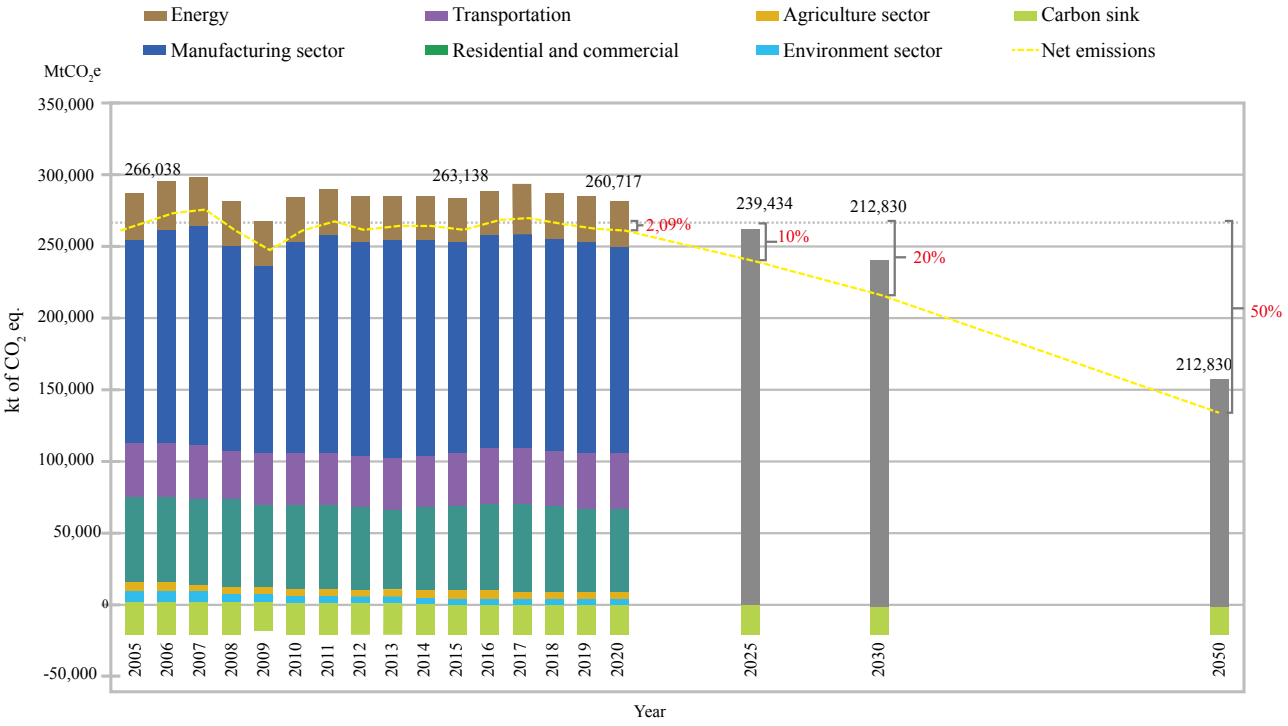


Figure 4.3.4 Projections of total GHG emissions

Source: Executive Yuan EPA, Phase I Greenhouse Gases Regulatory Goals in Stages.

Reference

1. Industrial Technology Research Institute, About TIMES Energy Engineering Model, What You Want to Know about—Introduction to Taiwan TIMES Energy Engineering Model, Understanding Energy BLOG. http://doenergytw.blogspot.com/2018/05/times.html

2. The Executive Yuan COA Planning Office, Estimation of Trends in Greenhouse Gas Emissions from Non-Fuel Combustion in the Agricultural Sector of Taiwan, July 11, 2017.

3. he Executive Yuan COA Planning Office, Estimation of Trends in Greenhouse Gas Emissions from Non-Fuel Combustion in the Agricultural Sector of Taiwan, July 11, 2017.

4. National Development Council, Report of Population Estimation of Taiwan (2018-2065), August 30, 2018.

5. National Development Council, Current Economic Situation, August 31, 2018.

▲Ta Shee Blooming Oasis

Chapter 5
Climate Change Observation and Science Study

Chapter 5
Climate Change Observation and Science Study

Most of the studies on climate change involve interdisciplinary integrated studies. Only by accumulating long-term meteorological observations and analyzing the climate change trend in Taiwan can we further estimate the impact of climate change and develop adaptation strategies. This chapter focuses on meteorological information and observations in Taiwan. It summarizes the involvement and participation of various ministries in climate change research or meteorological observation implementation and results and introduces the nation's current climate observation, including meteorology, sea states and hydrological systems. Moreover, it presents the results of Taiwan's climate change research projects in recent years, and finally outlines the future planning of meteorological research and observation.

5.1 Meteorological observation system

Taiwan's meteorological system observation is mainly based on the observation system established by the MOTC Central Weather Bureau (CWB), while other government agencies build monitoring stations as needed by the business, such as the MOEA Water Resources Agency, the Executive Yuan Council of Agriculture and the Executive Yuan Environmental Protection Administration. These observation systems include ground-based and high-altitude weather observations, meteorological radar observations, sea states and hydrological observations. They cover various meteorological elements and atmospheric data, such as wind direction, wind speed, rainfall, barometric pressure, temperature, hydrology, sea state, ultraviolet ray, air quality and atmospheric composition, in addition to meteorological satellite observation. Aside from receiving satellite information from the United States and Japan, the FORMOSAT-3/COSMIC satellites developed by the National Space Organization of the National Applied Research Laboratories observe global atmospheric conditions and provide the data to meteorological institutions worldwide and in Taiwan. Therefore, Taiwan has constructed a national, regional and global observational network of meteorological systems at different scales and levels. The following elements are explained separately:

1. Ground-based and upper-air meteorological observation

The CWB's existing surface meteorological observation services include not only general surface meteorological observation and forecasting operations but also the atmospheric, physical and chemical observations, intensive automatic rainfall observation networks and agrometeorological observations. Ground-based meteorological observations performed by general synoptic weather stations refer to the direct observation using visual inspections or surface-mounted meteorological observation instruments by observers of various meteorological elements near the lower atmosphere, such as air pressure, temperature, humidity, rainfall, wind speed, wind direction, cloud amount, cloud shape, cloud (base) height, daily radiation, sunshine hours, evaporation, soil temperature, visibility and weather phenomena. Most of the existing surface meteorological observation operations have been automated.

Surface and high-altitude meteorological observations are carried out by synoptic weather stations, unmanned automatic rainfall stations,

and automatic weather stations. The synoptic weather stations conduct regular observations in accordance with the operating procedures of surface meteorological observations and forecasts. Taiwan's meteorological observation service began as early as in1885. There was an aggregate of 27 synoptic weather stations in Taiwan proper and outlying islands as shown in Table 5.1.1, while there are 542 unmanned automatic rainfall stations and automatic weather stations.

The CWB has radiosonde stations at Banqiao, Hualian, Yongkang, and Dongsha Island. Each station uses the same type of receiving system. Normally, according to the World Meteorological Organization, the stations carry out two sounding operations a day, while the Dongsha station performs one sounding operation a day. The observation results are transmitted back to the CWB in real time by network or satellite line and then exchanged with international organizations at the same time.

Regarding agrometeorological observation, the CWB and the COA have been jointly implementing the four-year (2016-2019) program of "Establishment of agrometeorological disaster risk indicators and disaster adaption strategies." In addition to the annual replacement, upgrading and automation of the observation instruments at the existing stations of the agrometeorological observation networks, several agrometeorological stations have been set up. This way, the observation quality and data density of the agrometeorological network is strengthened to provide a reference for the establishment of agrometeorological disaster risk indicators and disaster adaption decisions. Up to the end of 2018, instruments at the 35 stations will have been replaced and upgraded, six stations added and 41 agrometeorological stations built. The distribution of all CWB stations across Taiwan is shown in Figure 5.1.1.

In terms of air quality and atmospheric composition monitoring, the CWB Taipei and Chenggong stations monitor the total ozone, the Lanyu station monitors the background atmosphere, the Banqiao station observes the vertical ozone profile, 18 weather stations measure rainwater acidity and alkalinity values and 20 weather stations measure the ultraviolet index. The EPA has also built an air quality monitoring network (including 60 general air quality monitoring stations, five industrial air quality monitoring stations, six traffic air quality monitoring stations, two national park air quality monitoring stations, five background air quality monitoring stations, 10 photochemical assessment monitoring stations and other special air quality monitoring stations, such as mobile monitoring vehicles and research monitoring stations) to conduct routine observations of air quality, ultraviolet radiation, photochemical pollutants, dust storms and greenhouse gases (GHG).

2. Meteorological satellite observation

At present, the CWB routinely receives and processes data from the synchronous meteorological satellite and polar-orbiting meteorological satellite. Additionally, the FORMOSAT-3/COSMIC satellites, launched by the country, play an important role in providing meteorological data. The following are explained separately:

1) Synchronous meteorological satellite (SMS)

The synchronous meteorological satellite (SMS) orbits the Earth at the same speed as the Earth's rotation speed. Taiwan receives SMS data mainly from the Himawari-8 satellite of Japan. Located at 140.7 degrees east longitude and 36,000 kilometers above the equator, the satellite provides two observation strategies including routine (full

Table 5.1.1 List of synoptic weather stations under the Central Weather Bureau

Station no.	Weather station	Elevation (m)	Longitude	Latitude	City/county	Data start year
466880	Banqiao	9.7	121.442	24.9976	New Taipei City	1972/3/1
466910	Saddle	825.8	121.53	25.1826	Taipei	1937/1/1
466920	Taipei	6.3	121.515	25.0377	Taipei	1896/01/01
466930	Jhuzihhu	607.1	121.545	25.1621	Taipei	1937/1/1
466940	Keelung	26.7	121.741	25.1333	Keelung	1946/1/1
466950	Pengjia Islet	101.7	122.08	25.628	Keelung	1910/1/1
466990	Hualien	16	121.613	23.9751	Hualien County	1910/1/1
467050	Sinwu	20.6	121.048	25.0067	Taoyuan	2013/7/1
467060	Su'ao	24.9	121.857	24.5967	Yilan County	1981/7/1
467080	Yilan	7.2	121.757	24.764	Yilan County	1935/1/1
467110	Kinmen	47.9	118.289	24.4073	Kinmen County	2004/1/1
467300	Dongjidao	43	119.668	23.257	Penghu County	1962/1/1
467350	Penghu	10.7	119.563	23.5655	Penghu County	1896/01/01
467410	Tainan	40.8	120.205	22.9932	Tainan	1897/01/01
467440	Kaohsiung	2.3	120.316	22.566	Kaohsiung	1931/1/1
467480	Chiayi	26.9	120.433	23.4959	Chiayi City	1968/9/1
467490	Taichung	84	120.684	24.1457	Taichung	1896/01/01
467530	Alishan	2413.4	120.813	23.5082	Chiayi County	1933/1/1
467540	Dawu	8.1	120.904	22.3557	Taitung County	1939/1/1
467550	Yushan	3844.8	120.96	23.4876	Nantou County	1943/1/1
467571	Hsinchu	26.9	121.014	24.8279	Hsinchu County	1991/7/1
467590	Hengchun	22.1	120.746	22.0039	Pingtung County	1896/01/01
467620	Lanyu	324	121.558	22.037	Taitung County	1941/1/1
467650	Sun Moon Lake	1017.5	120.908	23.8813	Nantou County	1940/1/1
467660	Taitung	9	121.155	22.7522	Taitung County	1901/1/1
467770	Wuci	31.7	120.523	24.256	Taichung	1976/11/1
467990	Matsu	97.8	119.923	26.1693	Lienchiang County	2004/1/1

Source: MOTC Central Weather Bureau

disk) and fast scanning (typhoon observation). Using multi-channel and high spatial-temporal resolution of observation data updated every 10 minutes or less, which not only offer real-time weather system monitoring information, but also develop more weather and environment monitoring products than previous operational satellites, thus enhancing the ability of monitoring and forecasting weather systems, and safeguarding people's lives and property. The observation instrument mounted on the Himawari-8 satellite has three visible bands, three near infrared rays and 10 infrared band channels, with the spatial resolution between 0.5 and 2 km.

2) Polar-orbiting meteorological satellite (POMS)

Polar-orbiting meteorological satellites (POMS) continue to circle the Earth in nearly north-south directions. In every orbit around the Earth, the satellites must pass through the Arctic and Antarctic poles of the Earth. The nation receives POMS data mainly from the US' SNPP and NOAA20. The CWB processes the observations of the Visible Infrared Imaging Radiometer Suite (VIIRS) of the two satellites, increasing the spatial resolution to 375 meters or 750 meters and improving the accuracy of a range of products, which is conducive to

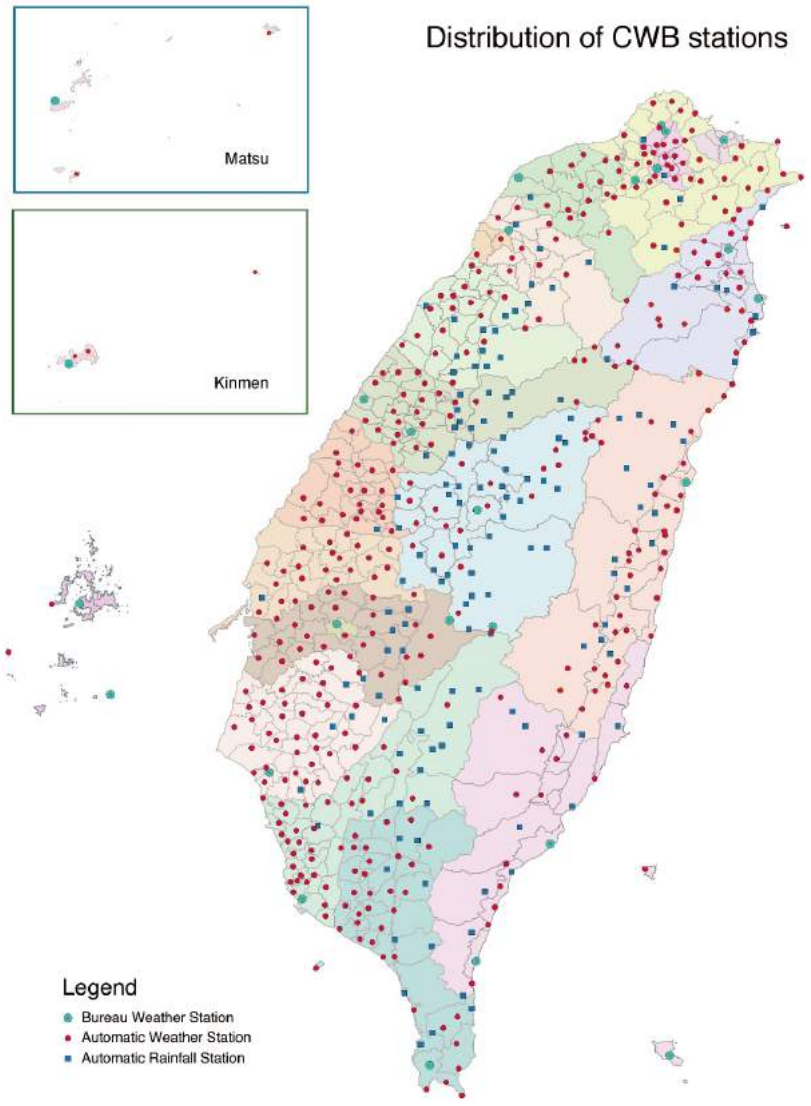


Figure 4.3.4 Projections of total GHG emissions

Source: Executive Yuan EPA, Phase I Greenhouse Gases Regulatory Goals in Stages.

measuring cloud and aerosol properties, ocean color, ocean and land surface temperature, ice-covered areas, fires and the albedo of the Earth.

3) FORMOSAT/COSMIC programs

A large bilateral international cooperation project between Taiwan and the United States, which was approved by the governments of both sides, the FORMOSAT-3/COSMIC program was conducted by the National Space Organization (NSPO) of the National Applied Research Laboratories (NARLabs) on the Taiwanese side and the University Corporation for Atmospheric Research (UCAR) on the U.S. side, with the aim to establish an advanced global atmospheric instant observation network, also known as the Constellation Observing System for Meteorology, Ionosphere and Climate (FORMOSAT-3/COSMIC). The GPS meteorological measuring instrument on board of the satellite can receive signals from the US' 24 GPS satellites. By measuring radio occultation signals, the atmospheric state distribution with altitude and global meteorological parameters can be derived.

FORMOSAT-5 is the first satellite in the remote sensing satellite program proposed by the "Phase 2 National Long-Range Plan for Space Science and Technology Development." An advanced ionospheric probe (AIP) developed by an R&D team of National Central University is aboard Formosat-5 to observe ionospheric changes. The optical resolution of FORMOSAT-5 images is higher than that of FORMOSAT-3, the image taken can be used for disaster prevention and meteorological data collection.

Also a large-scale international cooperation program between Taiwan and the United States, FORMOSAT-7—the follow-up project of FORMOSAT-3—is being undertaken by the NARLabs NSPO of Taiwan and the US National Oceanic and Atmospheric Administration (NOAA). The program aims to establish a various highly reliable operational meteorological satellite constellations and continue the occultation meteorological observation mission of FORMOSAT-3, and it is scheduled to be launched into orbit at the end of 2018. FORMOSAT-7 will deploy six mission satellites in low-dip (24 degrees) orbit to intensively provide more meteorological observation data in the middle to low latitudes, which will increase the amount of observation data in Taiwan. The satellites will be used in the CWB numerical forecasting system to improve the accuracy of domestic weather forecasting and prediction of severe weather (typhoon track and rainfall). It will be of great help to the collection of sea surface data and global weather forecasting and climate observation.

3. Meteorological radar observation

The CWB currently has four S-band (10cm wavelength) radars: three Doppler weather radars, which are located in Hualien in the east, Kenting in the south, and Qigu in the west, and one set of fdual-polarization Doppler weather radar, which is located in Wufenshan in the north of Taiwan. Additionally, with the C-band Doppler weather radars of the Civil Aeronautics Administration, Air Force and other meteorological units, the scanning range covers Taiwan proper and adjacent sea areas, forming a complete weather radar observation network (as shown in Figure 5.1.2). Besides typhoons from the Pacific, the South China Sea, and the Bashi Channel, weather systems such as plum rain and cold waves can also be observed. Furthermore, two C-band (5cm wavelength) dual polarization precipitation

radars were completed in 2017 and 2018, located in Kaohsiung's Linyuan District and Taichung's Nantun District respectively—and three homotype radars are planned to be built in 2019 in New Taipei City's Shulin District, Yunlin County's Kouhu Township and Yilan County's Zhuangwei Township. They can provide rainfall grid data with a radial resolution of approximately 250 meters, within a scanning radius of 75 kilometers every 2 minutes for water resources and disaster prevention departments, as shown in Figure 5.1.2.

The Quantitative Precipitation Estimation and Segregation Using Multiple Sensor (QPESUMS) is a weather information system developed jointly by the CWB, the Water Resources Agency, the Soil and Water Conservation Bureau and the US National Severe Storms Laboratory. The system integrates multiple observation data from rainfall stations, radar stations and satellite observations and develops a severe weather monitoring system based on geographic information to provide real-time severe weather monitoring information, quantitative precipitation estimation in the past 72 hours and products for quantitative precipitation forecast in the next one hour. By the end of 2017, the QPESUMS had been installed in the MOEA Water Resources Agency (WRA) proper, the WRA Tenth River Management Office, the National Science & Technology Center for Disaster Reduction, the Air Force Weather Center, the MOI National Fire Agency (NFA), the COA Soil and Water Conservation Bureau, the Taipei City Government Fire Department, the Comprehensive Center for Disaster Research of National Taiwan University, and the NFA disaster prevention and response centers in cities and counties.

4. Marine weather and hydrological observation

The CWB has set up a marine weather observation network around the island and off-island. There are 36 observation stations, including nine data buoy stations and 26 tide level stations. The observation items of tide level stations include tide level, and some tide level stations including water temperature. The observation interval of the buoy station is one hour, and its observation items include wave height, wave direction, wave period, wind speed, sea temperature, air temperature, air pressure, flow velocity and flow direction. The CWB marine weather observation network is presented in Figure 5.1.3.

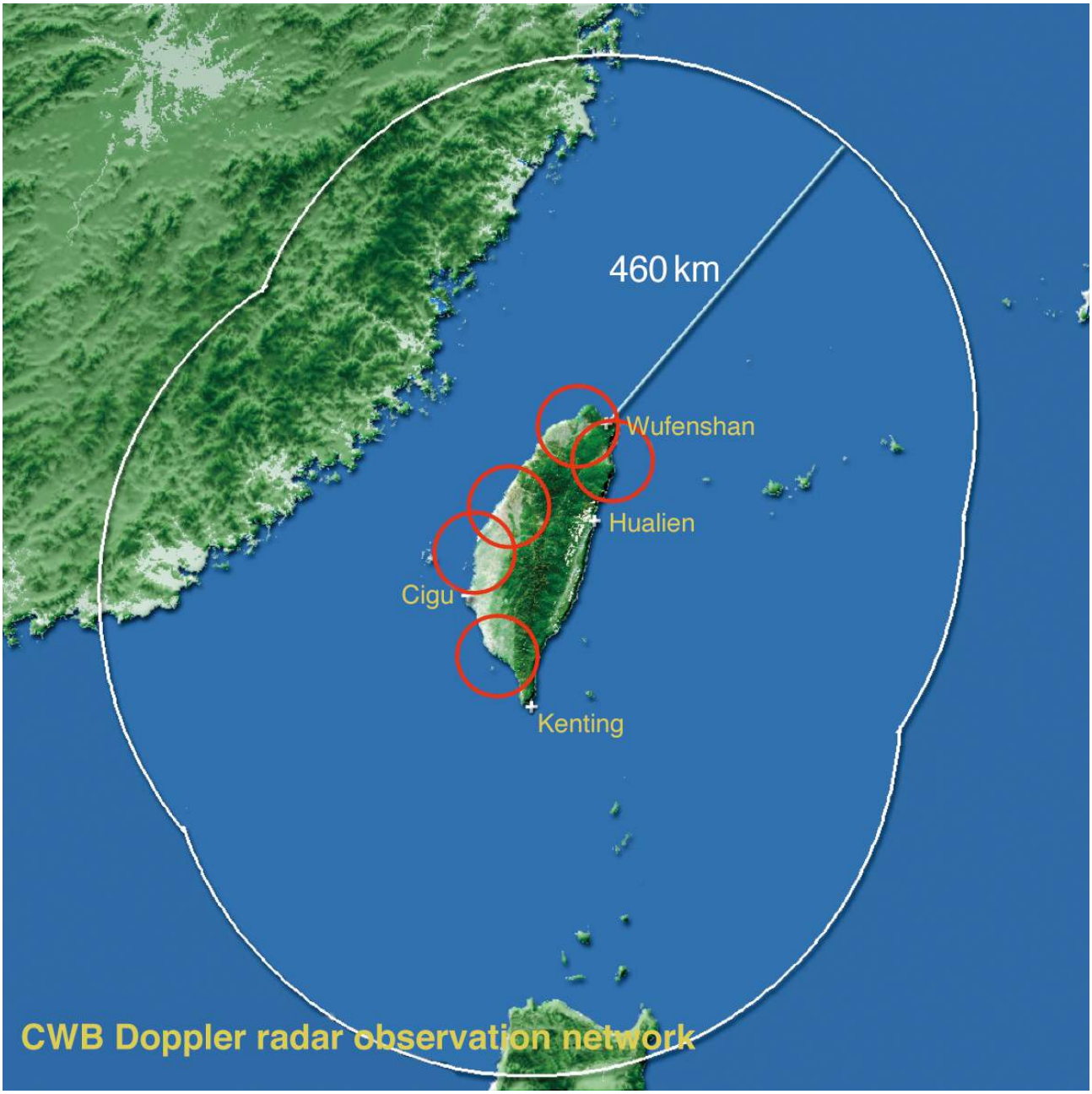


Figure 5.1.2 Taiwan's meteorological radar observation network

Source: MOTC Central Weather Bureau (CWB).

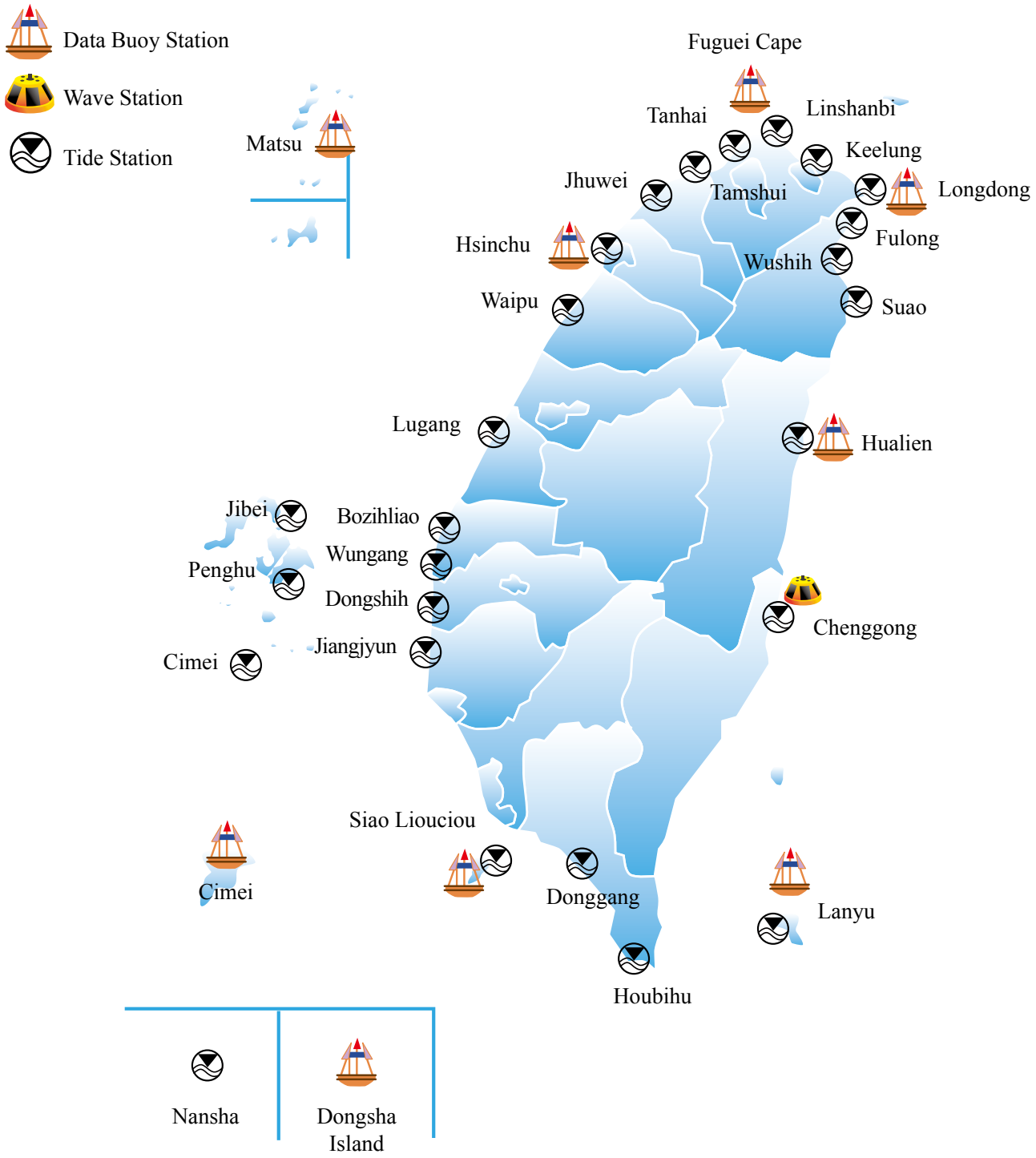


Figure 5.1.3 CWB marine weather observation network

Source: MOTC Central Weather Bureau (CWB).

To keep abreast of the coastal hydrological situation around the island and collect the coastal hydrological data for the coastal disaster prevention operations and the sustainable development of coastal zones, the MOEA Water Resources Agency (WRA) has developed a prototype of operational marine weather observation system, which includes on-site observation stations, instant data transmission systems, monitoring quality control systems and data display systems. By the end of 2017, there were 19 stations in the offshore hydrological observation network, including seven data buoy stations and 12 tidal level stations. In terms of river hydrological monitoring, 212 river rainfall monitoring stations, 260 water level, discharge and sediment concentration monitoring stations, 365 groundwater level observation stations (778 wells), and 11,674 large cross-section piles of the river, have been deployed in rivers, catchment areas and groundwater source areas throughout the nation.

5.2 Key research and promotion work on climate change

The CWB is committed to improving its capabilities in meteorological observation, forecasting and climate change research. In 2010, the "Disastrous Weather Monitoring and Forecasting Operations Construction Program (2010-2015)" and the "Climate Change Application Service Capacity Development Program (2014-2017)" were launched in 2014. Its research focused on climate model development and application, climate change analysis and climate application promotion. The interaction between the CWB and climate-related projects is shown in Figure 5.2.1.

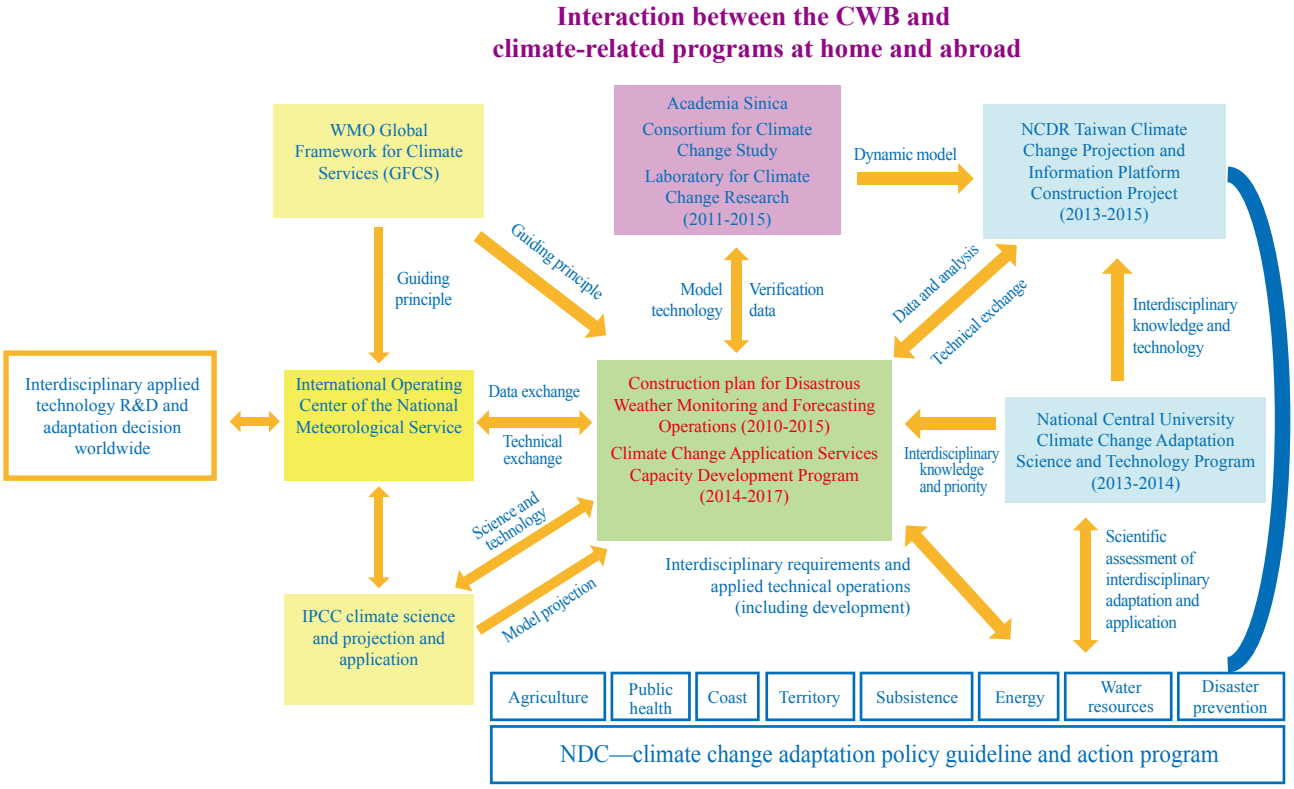


Figure 5.2.1 Interaction between the CWB and climate-related programs at home and abroad

Source: MOTC Central Weather Bureau (CWB).

In addition to enhancing the capabilities of observation and research, the Ministry of Science and Technology (MOST) also used climate science data, accumulated over the last century as a basis for formulating response and adaptation measures as well as decision-making on climate changes. MOST also develops scientific research on climate change and performing specific impact assessment. Since 2010, the agency had successively promoted three major scientific research projects on climate change: Consortium for Climate Change Study (CCliCS) (2011-2016), Taiwan Climate Change Projection and Information Platform (TCCIP) (2010-2016), and Taiwan Integrated Research Program on Climate Change Adaptation Technology (TaiCCAT) (2011-2016). The primary outputs of the three research projects included the establishment of local climate change models in Taiwan, the introduction of US high-resolution models, the building of climate change databases, the provision of downscaling data for climate change estimation, the provision of scientific data services for climate change, the construction of vulnerability and interdisciplinary assessment tools and the development of risk assessment and adaptation processes.

In 2017, the MOST, with the goal of developing an integrated platform for climate change services based on past research, initiated the "Taiwan Climate Change Estimation Information and Adaption Knowledge Platform Program," with the National Science and Technology Center for Disaster Reduction (NCDR) as the project office, integrating and extending into a complete climate change integrated service platform. Other administrative units in the country also conducted climate change research on the areas under their jurisdiction, as described separately below:

1. Consortium for Climate Change Study (CCliCS)

The Consortium for Climate Change Study (CCliCS) brings together researchers with rich experience in climate research, model development and simulation in Taiwan. Based at the Laboratory for Climate Change Research of the Academia Sinica and partnering with the academics from National Taiwan University, National Central University, and National Taiwan Normal University, the CCliCS trains climate change simulation teams lacking in Taiwan on a five-year period and fosters the key capabilities needed for the nation's climate change simulation and interpretation.

The CCliCS is directed towards the establishment and development of models and the study of climate change and variation. The model establishment and development include the Earth system model and the high resolution global atmospheric model, the aerosol and cloud microphysics and the construction and development of regional climate models. It has built a set of Earth system model groups and database that can be modified and developed domestically. The groups include the Earth system model, high-resolution (less than 20km) global atmospheric model and ultra-high resolution regional model. For the Earth system model, the Community Earth System Model (CESM1) was introduced from the US National Center for Atmospheric Research. The model includes physical and chemical processes such as atmosphere, land surface, ocean, and biogeochemical cycle and simulates the effects of interactions among systems on climate variability and change. Climate change and variation studies include detection and attribution, severe weather, high-resolution climate change simulation and

estimation, climate change mechanism simulation and Coupled Model Intercomparison Project Phase 5 (CMIP5) global/monsoon climate change assessment.

2. Taiwan Climate Change Projection and Information Platform (TCCIP)

Ran from 2010 to 2016, the primary objective of the TCCIP Phase I project was to provide reliable, objective and local climate change scientific data. In addition to constructing long-term observation data and producing predictive climate data in Taiwan, the project also set up an information platform website to provide complete and local downscaling climate data of Taiwan for scientific research communities. The TCCIP also serves as a bridge between producers of climate change data, such as meteorologists and data users and experts in related fields, to effectively transmit to users the analysis results, estimated data and information of producers. The TCCIP platform has collected 1.5 billion pieces of big data and 100,000 images on climate change, homogenized and gridded climate change data in Taiwan and boosted the temporal and spatial resolution of the data, which would be of great help to relevant scientific research about climate change impact on the nation.

The TCCIP program also worked with the SOUSEI program by the Ministry of Education, Culture, Sports, Science and Technology, Japan, to exchange information, data application experience and related technologies. The TCCIP carried out data R&D and upgrade, applied them to various impact areas, and formulated adaption policies. Coordinated and planned by the NCDR, it involved 21 institutions, including the MOTC CWB, the Executive Yuan COA Agricultural Research Center, the Centers for Disease Control of the Ministry of Health and Welfare, the Academia Sinica Research Center for Environmental Changes, the National Health Research Institutes National Institute of Environmental Health Sciences, the NARLabs National Center for High-Performance Computing, the NCDR, National Taiwan University, National Taiwan Normal University, National Taipei University, National Chiao Tung University, National Central University, National Taiwan Ocean University, University of Taipei, and Chinese Culture University.

5.2.1 Improvement of Taiwan's meteorological observing and forecasting ability and climate change research ability

1. Development and application of meteorological models

In addition to upgrading the meteorological observation system, the CWB has worked on the climate model development to establish monthly and quarterly disastrous weather trend analysis and forecasting technology, which strengthens the professional ability to analyze severe weather from a climatic viewpoint, and supports the government in establishing a more sound natural disaster risk management mechanism, assisting with the full use of climate data in the production of economic benefits. By understanding and managing weather and climate risks, it has proposed an Action Plan for Improving Climate Prediction. Through global climate forecasting, it has set up a dynamic statistical forecasting system, a climate simulation capability and system and a 30-year hindcasting database for predictability assessment and for the estimation and forecast of Asian monsoons and northwest typhoons. Regarding Taiwan's climate prediction, the CWB has developed statistical

forecasting methods and established statistical and dynamic downscaling methods to estimate the temperature and precipitation by zone in Taiwan. Meanwhile, it has been improving its ability to forecast, apply, and analyze data, and predicts the occurrence of drought, rainstorms, spring rain, cold and heat waves through the identification of disaster-prone weather and the analysis and prediction of the characteristics of disaster-prone weather systems. It also uses the ocean climate coupling model to introduce the ocean model, build an ocean-air coupling model, and carry out climate simulation and prediction, so as to estimate El Niño and La Niña. The purpose of this study aims to achieve simultaneous monitoring with advanced meteorological services in the world, predict the development potential of climate and disastrous weather systems, and estimate weather and climate risks, as shown in Figure 5.2.3.

Climate is the long-term average state of the atmosphere, but the development of the whole climate system is not only affected by the changes of the atmosphere but also by the external environment. The land and the ocean on Earth, for example, can influence the changes of atmospheric circulation through the characteristics of the fluid, and the degree of influence will increase with time. Therefore, a complete climatic forecast model must include the prediction of ocean circulation, and even ocean fluctuations. The CWB climate prediction system has developed from two aspects: one is improving the resolution of the atmospheric model, and the other is incorporating the ocean circulation, prediction model. In the current operating system of climate prediction, the horizontal resolution of the atmospheric model has increased from the initial 300km (equatorial circle) to 100km, while the vertical direction has also increased from 18 to 40 layers. The forecast time has been extended from one month to nine months. The forecast information has been provided for all walks of life. The seasonal probability forecast of temperature and rainfall near the surface (2 meters above the ground) in the climate model is illustrated in Figure 5.2.4.

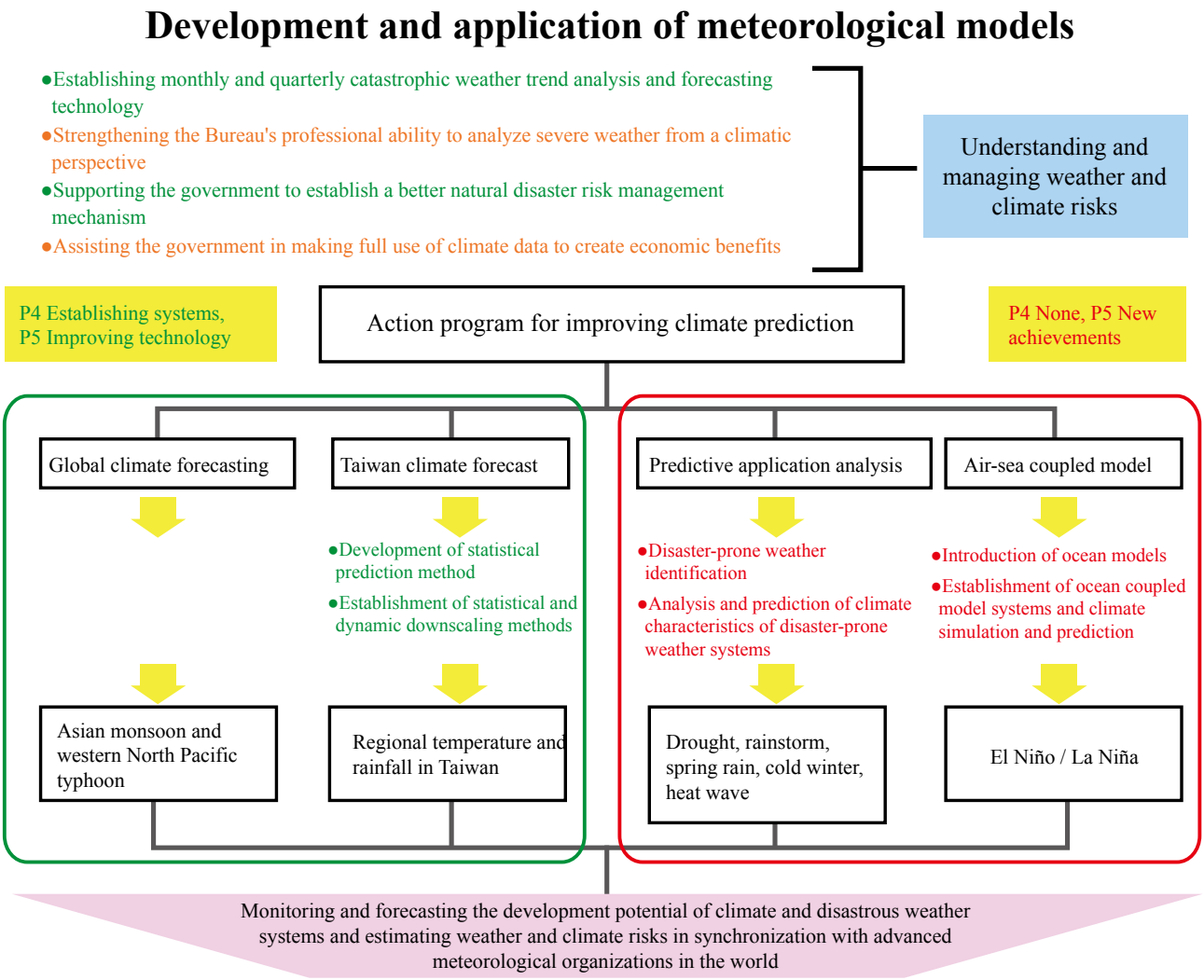


Figure 5.2.3 Development and application of CWB meteorological models

Source: MOTC Central Weather Bureau (CWB).

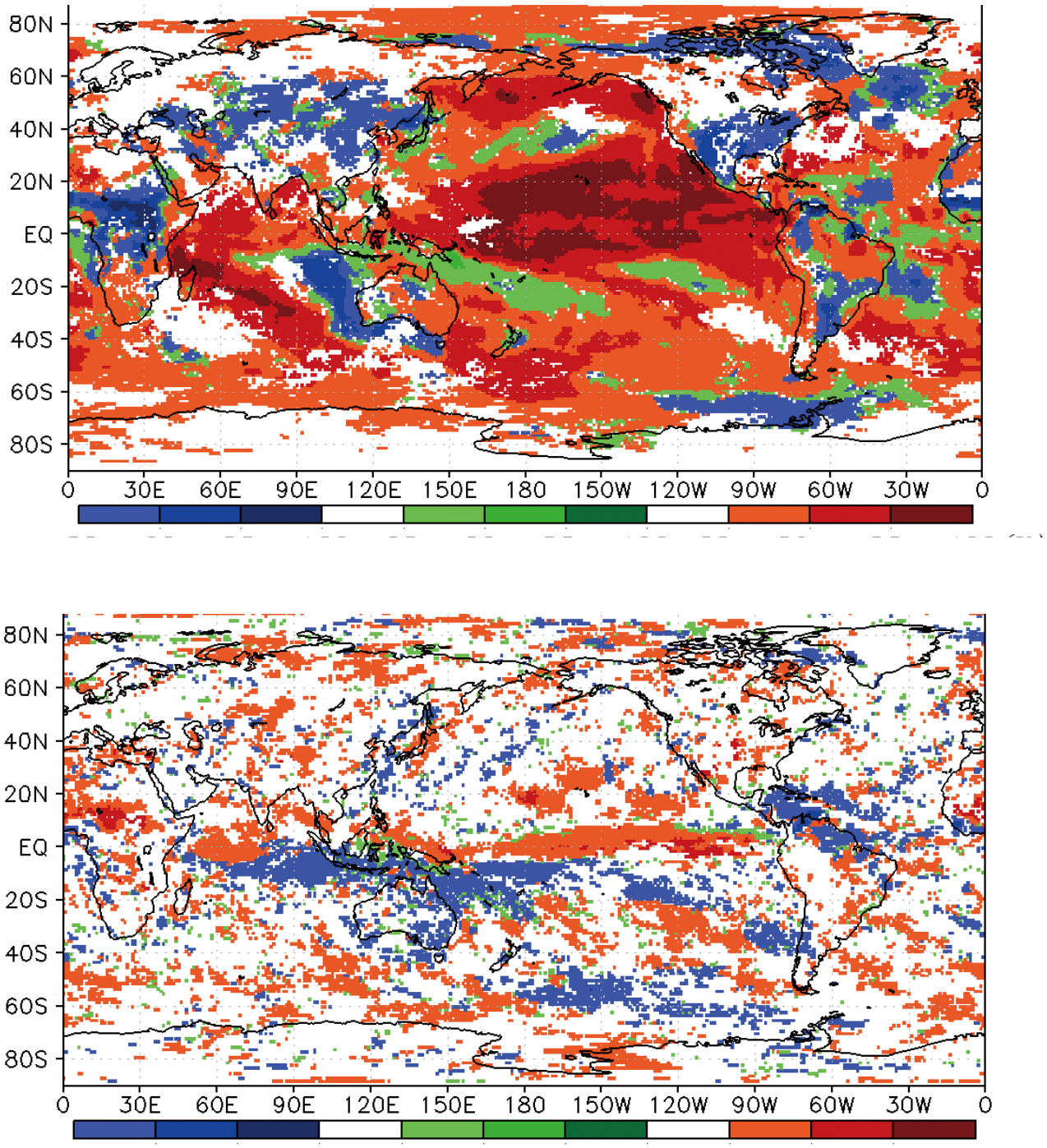


Figure 5.2.4 Seasonal probability forecast of near-surface temperature (upper) and rainfall (lower) in climate models

Source: MOTC Central Weather Bureau (CWB).

2. Climate Change Application Services Capacity Development Program

Since 2014, the CWB had developed and implemented a four-year “Climate Change Application Services Capacity Development Program (2014-2017)”. The objectives were to prepare and analyze long-term climate data, develop the capability of climate information application services, and promote climate knowledge and information application services in an attempt to cope with climate change, strengthen meteorological disaster prevention, and support national meteorological risk management and climate change adaptation and application. In line with the national climate change adaptation policy and action plan and the keen demand for climate forecasting information for decision-making in related fields, the CWB has expanded its climate research and application capabilities through "developing Taiwan's technological capabilities for climate change analysis and estimation" and "extending climate information application services."

1) Developing Taiwan's technological capability of climate change analysis and estimation

To assist the country with cushioning the impacts and effects of climate change, provide adequate information on climate change analysis and estimation and support national meteorological risk management and adaptation to climate change, the CWB had built a climate background database based on accumulated data from stations, analyzed past climate change in Taiwan to then estimated the impact of climate change on Taiwan, as shown in Figure 5.2.5.

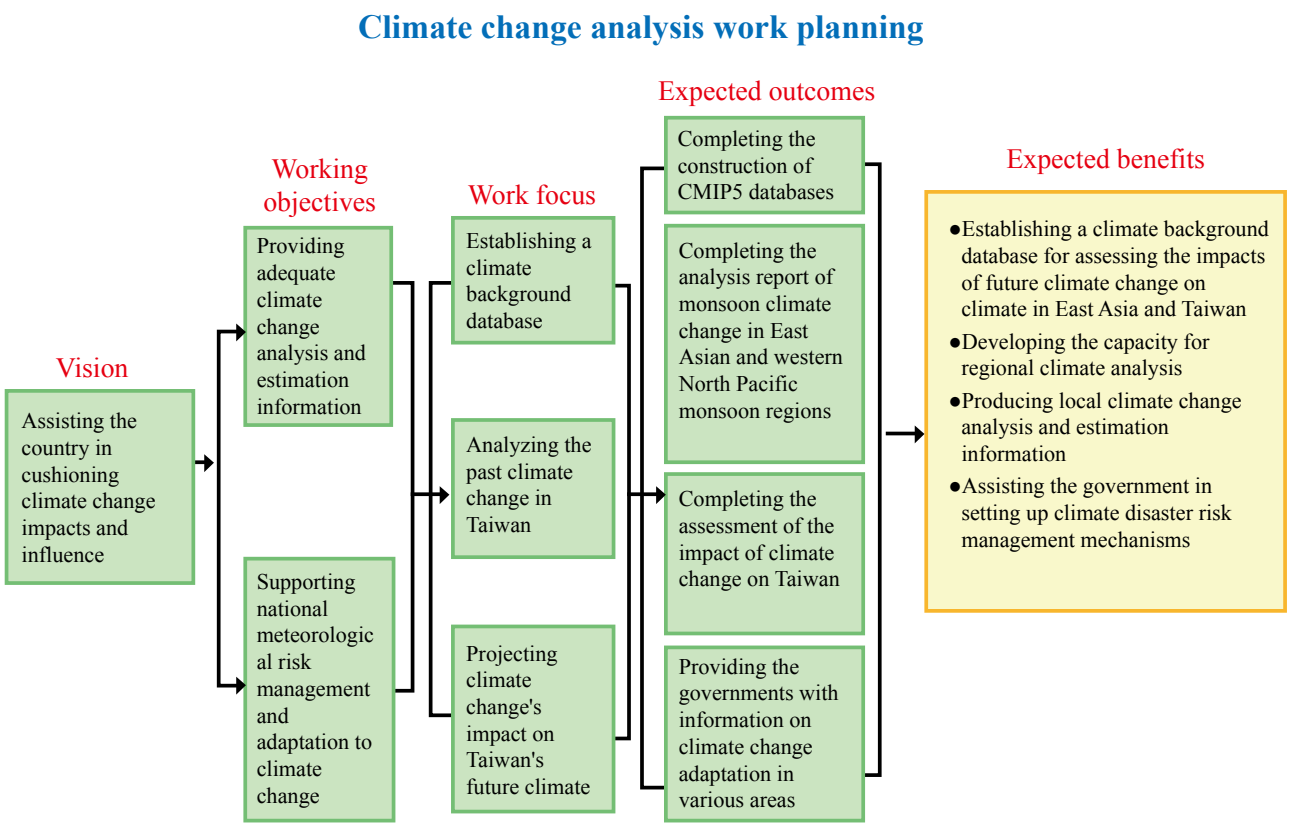


Figure 5.2.5 CWB climate change analysis work planning

Source: MOTC Central Weather Bureau (CWB).

2) Climate information application service

In order to expand the scope of climate application services in the country, the CWB had developed its capability of climate information application services and promoted its climate information application services in recent years. Through the establishment of Taiwan's climate information operating application service architecture and mechanism design, and the development of climate risk assessment methods in various application areas, it had held interdisciplinary forums and seminars on climate application. It was scheduled to complete the design of the application service architecture and mechanism for climate and related change information in the nation, establish methods for climate risk assessment and application in various application fields, completing Taiwan's climate service demand survey report and providing climate change adaptation information in various application areas. Through this research project, it was expected to build up the CWB's climate application service capability, boost its effectiveness of climate information application service and support the government in establishing operational mechanisms for climate change risk management and adaptation, as shown in Figure 5.2.6.

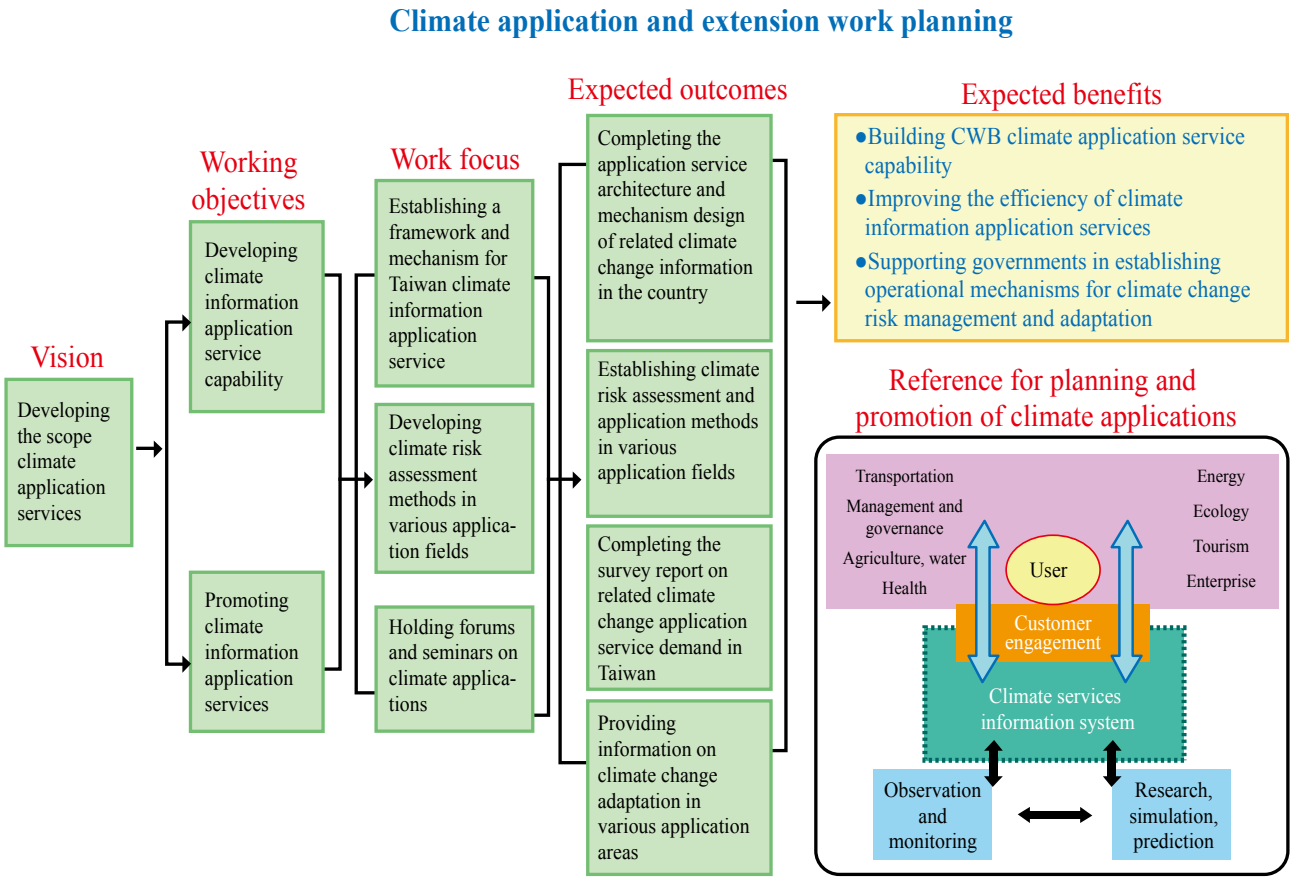


Figure 5.2.6 CWB climate application and extension work planning

Source: MOTC Central Weather Bureau (CWB).

5.2.3 Data application and information platform

1. Climate Change Application Service Capacity Development Program

Since 2014, the MOTC Central Weather Bureau (CWB) had implemented a four-year Climate Change Application Service Capacity Program. The objective was to prepare and analyze long-term climate data, develop the ability of climate information application service, promote climate knowledge and information application service to cope with climate change, strengthen meteorological disaster prevention, and support national meteorological risk management and adaptation to climate change.

In line with the national climate change adaptation policy and action plan, the strong demand for climate prediction information for decision-making in related fields in various application fields has led the CWB to review the sscarcity of resources in the past for the climate change analysis, estimation and practical adaptation, decision-making and application. For this reason, from 2014 to 2017, it expanded the capability of climate research and application by “developing Taiwan's technical competence of climate change analysis and estimation" and "extending climate information application services."

Through cooperation with different fields, the CWB promoted the interdisciplinary climate information application and service and provided the meteorological service information needed by users from all walks of life in the country. The CWB teamed up with relevant units of disaster prevention, agriculture and water resources. In the application of disaster prevention, for example, the CWB offered rainfall observation and forecast information to disaster prevention units as reference for flood control and debris flow early warning operations; and the QPESUMS to the MOTC Directorate General of Highways as reference for early warning and response measures. In terms of agriculture, the Bureau cooperated with the COA to operate and maintain the agrometeorological observation networks for provision of high-quality meteorological data in the agricultural sector. Regarding water resources, it offered early warning information on rainfall or drought for water resources units as a reference for water resources dispatching. The general distribution of the CWB’s agricultural cooperative application observation networks is demonstrated in Figure 5.2.7.

In addition to disaster prevention, agriculture and water resources, the CWB has also cooperated with the fishery and public health departments. In last few years, the Bureau has organized interdisciplinary climate application information forums and seminars, where relevant government operational units, agencies and school researchers and relevant industry practitioners were invited to promote horizontal communication, understanding users' needs, promoting meteorological services and developing the value of meteorological information application services. At present, many interdisciplinary forums and seminars have been held in the fields of agriculture, fisheries, water resources management, and public health. Moreover, it has also joined hands with government agencies and academic institutions in developing applications of meteorological information in various fields.

In agricultural applications, through the QPESUMS, the CWB assists the Livestock Research Institute in meteorological services for hay modulation. As hay is an important feed source for the dairy industry, the preparation process goes through lying flat for natural drying for 3-5 days after mowing. In the process, if it is not collected in time when it is raining, the grass will rot and lose its commercial value. Via the QPESUMS, administrators can set the

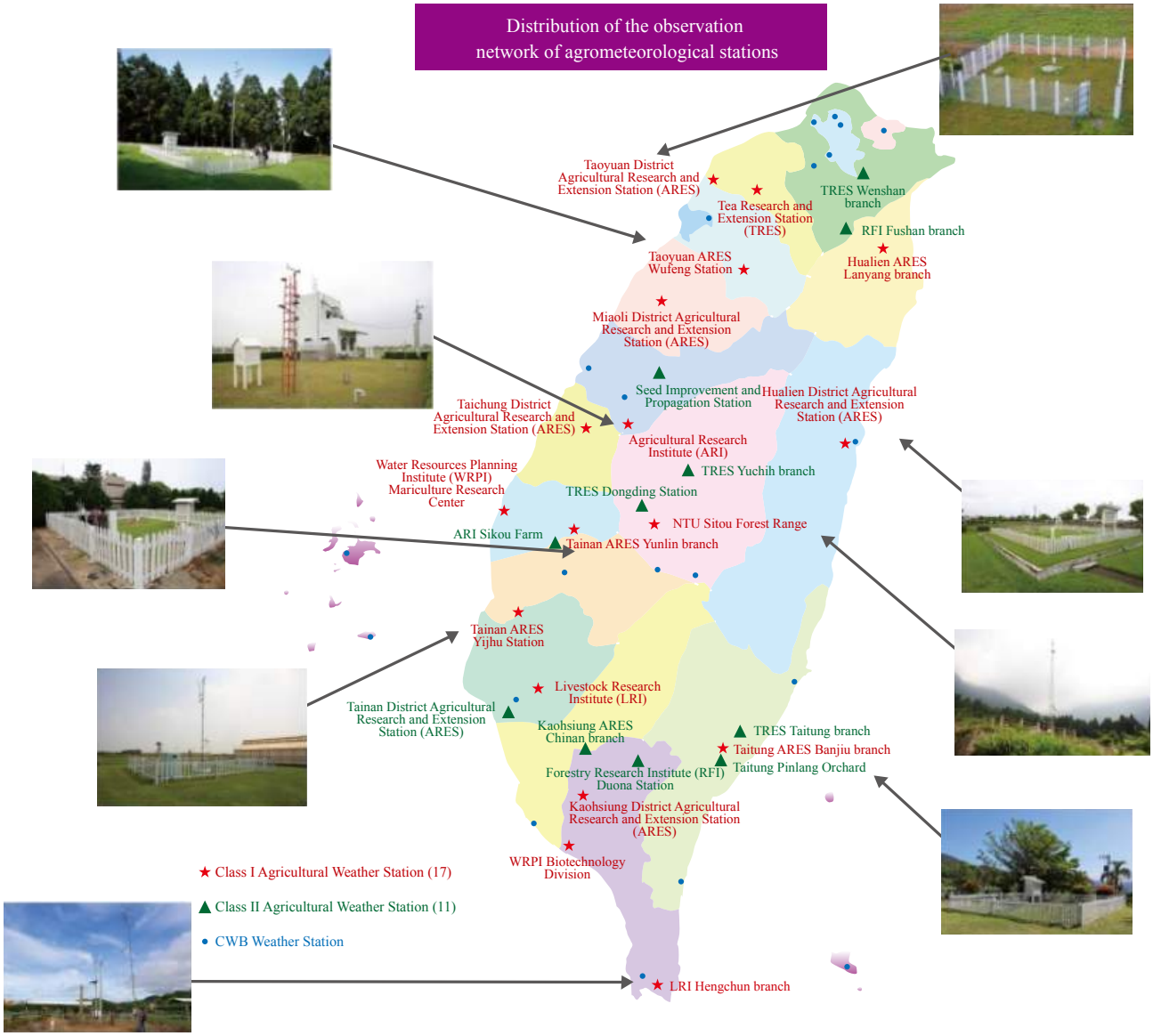


Figure 5.2.7 Distribution of CWB agricultural cooperative application observation networks

Source: MOTC Central Weather Bureau (CWB)

echo intensity and radius. When the threatening echo enters the radius, the system will automatically give an alarm, which enables administrators to mobilize manpower to fight for time for emergency handling and effectively reduce the rain damage. In recent years, with the high frequency of extreme or abnormal weather, the definition of responsibility for natural disasters or improper management, the scale of disasters, and the criteria for granting relief funds have become increasingly unclear. Therefore, the Executive Yuan COA Agriculture and Food Agency-the body in charge of dealing with the relief of agricultural natural disasters, relies on the CWB's observation data as scientific evidence to reduce disputes. The CWB has also set up an agro-expert meteorological consultation system for the Executive Yuan COA Agricultural Research Institute based on the Taiwan hyetograph and surface temperature diagram, insolation satellite inversion data, and periodic meteorological station data provided by the CWB, through the combination of the GIS system and

crop growth model. In a short-term application, it can provide farmers with real-time local weather conditions and early warning against pests and diseases. In a long-term application, it can estimate future output to regulate market supply and demand and improve farmers' income. At the same time, it also collaborates with the institute in compiling the first edition of teaching materials on agrometeorology and attempts to build a communication platform among end users (agricultural practitioners). Through the close cooperation with regional farmers' associations, successful examples for agrometeorological information users are expected to be established with contribution to the planning of future CWB relevant policies or measures, so as to improve the economic benefits of meteorological products for domestic agricultural users.

In terms of fishery application, it has worked closely with the Executive Yuan COA Fisheries Research Institute and Fisheries Agency in planning and producing the fine weather forecast of 47 aquaculture areas, the fishery meteorological special zone on the CWB website and the mobile communication fishery meteorological app.

5.3 Future planning

In the future, the CWB will promote the refined intelligent application of meteorological (weather) information, enhance Taiwan's ability to warn against natural disasters such as earthquakes and tsunamis, expand the application level of seismic information in disaster prevention, land and academia, strengthen marine meteorological observation facilities and forecasting technology and boosting marine disaster prevention and environmental services.

1. Future planning of climate models

In the future, the development of climate forecasting aims at establishing a coupled ocean-atmosphere forecasting system. The coupled system combines ocean circulation models with atmospheric ones while predicting the state of the ocean and atmosphere so that the two-way interaction between the ocean and atmosphere can be simulated with more accuracy. In addition, the horizontal resolution of the atmospheric model will rise to 50km, and the vertical direction to 60 layers, and the forecast time will be extended to 13 months, with more marine forecasting products to be added to estimate the scope of the use of forecasting data.

2. Application of meteorological services

1) Carrying out plans for the development of small-area disastrous weather real-time forecasting systems, meteorological science research and development, maintenance plans, related scientific and technological development plans, strengthening meteorological information infrastructure, developing new small-area disastrous and real-time weather forecasting technologies, developing localized probability-based forecasting guidelines and establishing operational mechanisms for disastrous weather warning, to meet the demand of disaster prevention and response and serving the people.

2) Carrying out the plan of building an environmental service system for marine weather and meteorological disaster prevention in Taiwan, by adding rainfall radars and new-generation satellite observation data with high time-space resolution and combining with new remote sensing data calculating technology in order to enhance the ability of radars and satellite data to detect and forecast

severe weather systems and produce the sea, air, land-related derivative products to boost the application value and service efficiency of remote sensing data.

3. Scientific and Technological R&D Program for Improving the Ability of Marine Meteorological Forecasting and Marine Environmental Disaster Prevention

1) Integrating the application of international marine meteorological data and open data from the Northwest Pacific, providing basic resources for science research in the sea area, promoting the application of marine meteorological data in scientific research institutes and government agencies, and creating marine weather advisory services for the marine economy and blue energy industry, developing service products such as sea temperature and cold damage warning, sea pollution and shipwreck drifting prediction, oceanic wave climate, ocean heat content, sea level change, storm tide and meteorological tsunami, and building Taiwan marine weather disaster prevention environment information platforms to provide disaster prevention information in specific sea areas.

2) Developing and building wave-tide coupled storm tide forecasting systems, developing linked storm surge models and typhoon track ensemble module technology, building storm tide ensemble forecasting systems, developing current data assimilation technology, strengthening and updating wave ensemble forecasting systems, introducing and building the latest version of wave model of the US National Weather Service, producing storm tide and wave probability prediction products, and reinforcing the capability of forecasting sea states.

3) Developing the abnormal wave probability early warning technology, establishing the freak wave probability early warning system, developing and integrating the auxiliary observation system to detect typhoons and their wave characteristics based on the seismic observation data and enhancing the ability of early warning against extreme and abnormal marine states.

4) To strengthen the environmental monitoring of disaster prevention and improve the ability of disaster prevention, early warning and response, a six-year (2015-2021) program of "Strengthening Environmental Monitoring of Marine Weather and Meteorological Disaster Prevention in Taiwan" has been implemented. The main tasks include: improving the performance of rainfall monitoring, adjusting and calibrating the existing rainfall station network on-site instruments, strengthening rainfall monitoring and transmission, reinforcing the establishment of Taiwan data buoy observation networks and tsunami warning buoys, building shore-based wave and current radar observation networks, setting up marine environmental disaster prevention service systems, developing wave-tide coupled storm tide forecasting systems, integrating coastal sea state information, building remote sensing disaster prevention service systems, developing satellite derivatives, developing quantitative rainfall forecasting technology in townships, and strengthening the convection system analysis and real-time forecasting ability, on the basis of remote sensing data.

4.Development of forecasting technology

The programs of "Intelligent Application Services of Meteorological Information (I)" (2016-2019), the "Application Services of Meteorological Information in Green Energy Development" (2017-2020), and the "Healthy Environment Shaping of Agriculture and Fishery—Using Customized Weather and Climate Information" (2018-20121) have been carrying out, with the contents as follows:

1) The "Meteorological Information Intelligent Application Service Program (I)" (2016-2019) focuses on (A) building a huge meteorological data platform and intelligent data optional function, integrating and strengthening the service efficiency of meteorological data supply; building 20 weather stations located on Taiwan proper and outlying islands; developing meteorological interdisciplinary service platforms, developing interdisciplinary application needs and promoting interdisciplinary application services; developing a new generation of modular QPESUMS-plus and introducing it to government disaster prevention departments as a priority; (B) developing a new version of air-sea coupled climate model and weather forecasting technology for Week 2 to Week 4, integrating the temperature forecasting model of stations in Taiwan and developing short-term climate comprehensive forecasting technology, conducting operational testing of spring rain trend prediction and optimizing plum rain trend prediction methods; improving regional model precipitation forecasting technology by refining radar data assimilation methods; building a second-generation refined forecasting operation editing system with a resolution of one kilometer and carrying out the localization and customization of a new-generation forecast decision support system and decision support tools; (C) expanding the resources of high-speed computing computers to support the development of high-resolution numerical models; optimizing the intelligent network management system of bureau-affiliated stations and planning the new backbone network of bureau-affiliated stations and building climate stations to strengthen the application services of local climate monitoring.

2) The "Application of Meteorological Information in Green Energy Development" program (2017-2020) focuses on: (A) integrating statistical mesoscale model simulation data, analyzing 1 km high-resolution wind energy density in better wind energy areas, introducing satellite and weather radar retrieval wind data, and analyzing 2 km-resolution surface solar energy density distribution, in order to build a new generation of green energy production value evaluation information prototype system and provide reference for wind power development, and (B) upgrading the resolution of the offshore wind farm demonstration area dynamic downscaling real-time operating system to 1 km, developing the wind energy statistical prediction system of the global forecasting model to refine the green energy generation forecasting system and the meteorological information green energy operational database system every six hours for the following seven days.

3) The "Healthy Environment Shaping of Agriculture and Fishery—Using Customized

Weather and Climate Information" program (2018-2021) focuses on developing interdisciplinary customized applications in the fishery, and completing the development of digital data and the production of image products for the sea surface temperature, polar orbiting satellite water color and night visible cloud imagery of the Japan's Himawari 8 weather satellite; (B) completing the coupling of the CWB's high-resolution global atmospheric forecast model with the multi-scale Taiwan community ocean model, and providing the fishing industry with interdisciplinary applications through customized systems to produce ocean elements such as sea temperature, sea salt, current and other meteorological and marine weather elements; (C) developing the interdisciplinary customized applications in agriculture, and analyzing climatic factors affecting the growth of the crop according to the demonstration crop selected by the COA Agricultural Research Institute and planning a dedicated and customized short-term climate forecasting system for this crop.

Reference

1. MOTC Central Weather Bureau, Surface Meteorological Observation Data Webpage: https://www.cwb.gov.tw/V7/eservice/docs/overview/observation/metro/sfc_obs.htm

2. MOTC Central Weather Bureau, Synchronous Meteorological Satellite Webpage: http://www.cwb.gov.tw/V7/eservice/docs/overview/observation/msc/gms.htm

3. MOTC Central Weather Bureau, High-altitude Meteorological Observation Data Webpage: http://www.cwb.gov.tw/V7/eservice/docs/overview/observation/metro/upper_air.htm

4. MOTC Central Weather Bureau, Agrometeorological Observation Webpage: http://www.cwb.gov.tw/V7/eservice/docs/overview/observation/metro/agr_metro.htm

5. MOTC Central Weather Bureau, Severe Weather Information System Website: http://qpesumspub.cwb.gov.tw/

6. MOTC Central Weather Bureau, Severe Weather Observing System Webpage: http://www.cwb.gov.tw/V7/knowledge/encyclopedia/ty081.htm

7. MOTC Central Weather Bureau, Polar-orbiting Meteorological Satellite Webpage: http://www.cwb.gov.tw/V7/eservice/docs/overview/observation/msc/sat1.htm

8. MOTC Central Weather Bureau Meteorological Satellite Center, Meteorological Remote Sensing Observation—Meteorological Satellite and Meteorological Radar, May 2015.

9. Executive Yuan Environmental Protection Administration, Air Quality Monitoring Network: https://taqm.epa.gov.tw/taqm/tw/default.aspx

10. Ministry of Science and Technology, Consortium for Climate Change Study (CCliCS) official website: http://cclics.rcec.sinica.edu.tw/index.php/about-us.html

11. Ministry of Science and Technology, National Science and Technology Development Program (2017-2020) (bound volume), September 2017.

12. Ministry of Science and Technology, Taiwan Climate Change Estimation and Information Platform: https://tccip.ncdr.nat.gov.tw/v2/about_us_1.aspx

13. National Cheng Kung University Coastal Ocean Monitoring Center official website: http://www.comc.ncku.edu.tw/chinese/d_observe/d_observe.htm

14. NARLabs National Space Organization, Introduction to the FORMOSAT-3/COSMIC Program https://www.nspo.narl.org.tw/tw2015/projects/FORMOSAT-3/program-description.html

15. Hsu, H.H., Hsu, C.C., Lee, W.L., Chen, C.H., Tsai, H.F., Hung, C.C., Lo, M.H, Huang, Y.T., Tu, C.Y., Tsai, Y.C., Lee, S.Y., and Wu, C.H., Integrated Study of Climate Change and Comparison of Transnational Climate Estimation Models, Consortium for Climate Change Study and CMIP6 Taiwan—Master Plan: Laboratory for Climate Change Research-II, 2017.

16. Hsu, H.H., Chen, C.P., Lin, P.L., and Chen, C.T., Establishment of Taiwan Climate Change Simulation Ability and Energy-Consortium for Climate Change Study (CCliCS), Natural Sciences Newsletter 27 (1), 2015.

17. MOEA Water Resources Agency, Hydrological Station Basic Information Webpage: http://gweb.wra.gov.tw/HydroApplication/WraSTList.aspx

18. MOEA Water Resources Agency, Climate Change Water Environment Knowledge Base: http://demosite.sinotech-eng.com/CCKMV2/Default.aspx

19. MOEA Water Resources Agency, Phase III Climate Change Impact on Water Environment and Adaption Research Management Report, 2017.

▲Yehliu Geological Park-Queen's Head

Chapter 6
Climate Change Impact and Adaptation Measures

Chapter 6
Climate Change Impact and Adaptation Measures

As an island, Taiwan foresees frequent earthquakes and typhoons due to geographical and geological factors, with the potential areas for disasters such as landslides and floods distributed throughout the nation. In recent years, the phenomena of global climate change and the influence of the greenhouse effect have become more and more evident. The constant increase of GHG emissions, the ongoing change of atmospheric composition, global temperature rise and the variation in the global climate operation mode all lead to the imbalance of global environment, ecology and economy. Extreme weather in the future is bound to aggravate the frequency and scale of calamities. How to adjust and adapt to the impact caused by climate change is an important issue we must face up to at present.

6.1 Current climate change impacts

1. Taiwan's climate model, estimation and situation

Taiwan's research and estimations of climate change are mainly based on the estimated and simulated results of the Coupled Model Intercomparison Project Phase 5 (CMIP5). The statistical downscaling method is used to present the regional characteristics of Taiwan and the possible range of probability distribution, as well as the dynamic downscaling simulation results of the regional climate model driven by the output of some of its models and high-resolution global climate models. The scenarios used in the new scenario design for the fifth assessment report of the IPCC (AR5) are based on the radiative forcing for estimating future climate change, and then on the Representative Concentration Pathways (RCPs) for estimating the time-dependent GHG concentrations. The global average radiative forcing values caused by atmospheric GHG concentrations by 2100 will be used by the IPCC as the basis for estimating future climate change.

Based on the current climate observation data in Taiwan, together with the international general observation and grid data, the characteristics of Taiwan's meteorological and component changes over the past century are combined to analyze and explain Taiwan's climate change trend as follows:

1) Estimation of temperature change trend and long-term temperature trend

The temperature in Taiwan slowly dropped from 1900 to the beginning of 1920, with the annual average and the winter half-year (November-April) average being the most obvious. Since the beginning of 1920, the temperature had risen until the recent period (see Figure 6.1.1), but the annual and winter half-year average did not rise or fall significantly between 1950 and the end of 1970 until the number climbed significantly after 1980 (see Figure 6.1.2). According to the temperature anomaly chart, the average temperature of the whole year and the summer half-year (May-October) increased by about 1.3°C while the winter half-year grew by 1.2°C (as shown in Table 6.1.1).

Average variations in near-surface temperature and climate in Taiwan are shown in Figure 6.1.3. It is estimated that the annual average temperature

change in the first period (2016-2035) is “more likely than not”—the probability is greater than 50%—in four different future rise scenarios, mainly between 0.3~0.9°C. There is little difference in the warming extent between different scenarios in this period. In the second period (2046-2065), except in the RCP 8.5 scenario, the average temperature is "more likely than not" to increase by 1.5~2.1°C, and the warming range in the RCP 4.5 scenario is relatively small, about 1.2~1.7°C. Furthermore, the warming range in the RCP 2.6 scenario is slightly smaller than that in the RCP 4.5 scenario. Except for the northern region, the warming in most areas is "more likely than not" to fall between 0.7 and 1.1°C. The warming in the RCP 6.0 scenario seems to be smaller than that in the RCP 4.5 scenario.

The time series trend of annual mean near-surface temperatures in Taiwan is shown in Figure 6.1.4. The green thick line in the figure is the result of the average of 5km grid observation data, the black thick line denotes the average value of the ensemble from the historical simulation experiment of climate models until 2005, and the grey interval is the interval range formed by the simulation and estimation results of individual climate models. The simulated estimates of climate models in RCP 8.5, RCP 6.0, RCP 4.5 and RCP 2.6 scenarios are represented by thick red, orange, blue and purple lines respectively, and the corresponding light-color intervals are also the interval ranges of the different estimates of individual climate models. The box-and-whisker plot on the right is the estimated distribution characteristics (including 90, 75, 50, 25 and 10 percentiles) for changes corresponding to the average model of the above different scenarios in the period from 2081 to 2100.

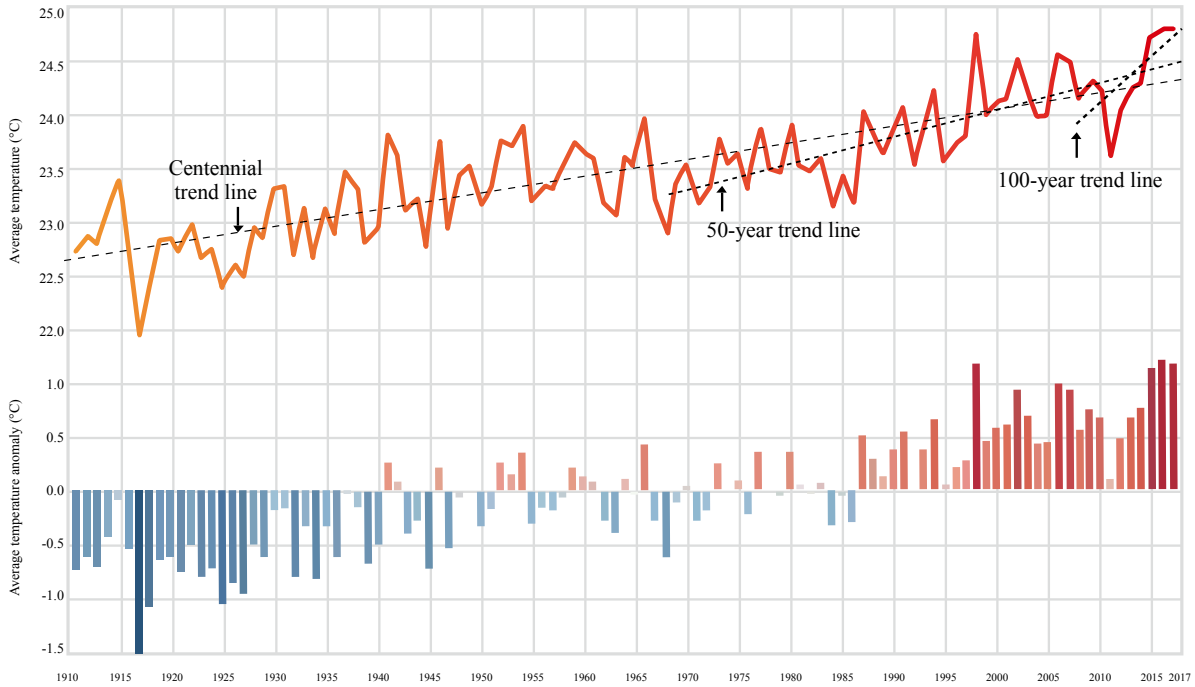


Figure 6.1.1 Observation of past temperatures in Taiwan: temperature trends from 1900 to 2017

Source: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

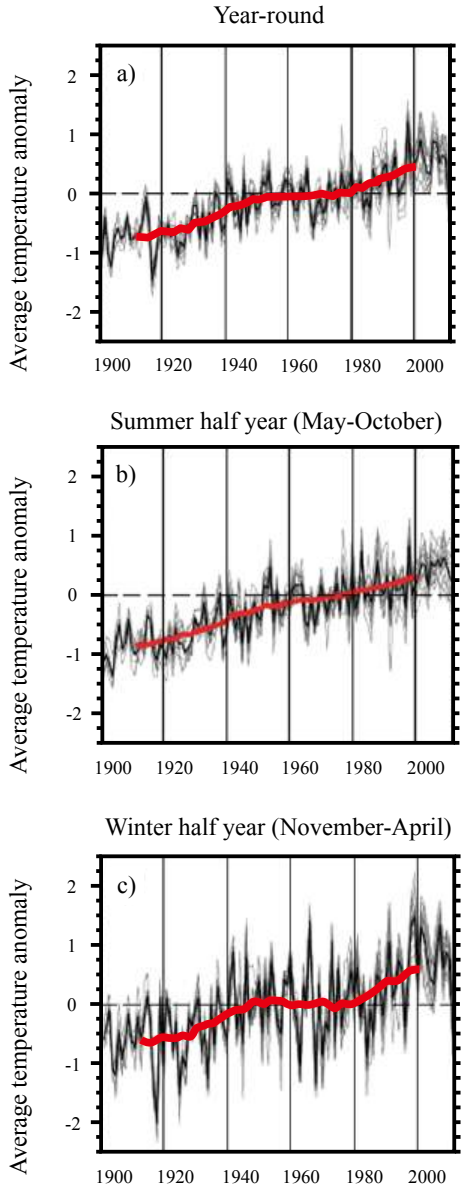


Figure 6.1.2 Temperature trends in Taiwan

Source: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

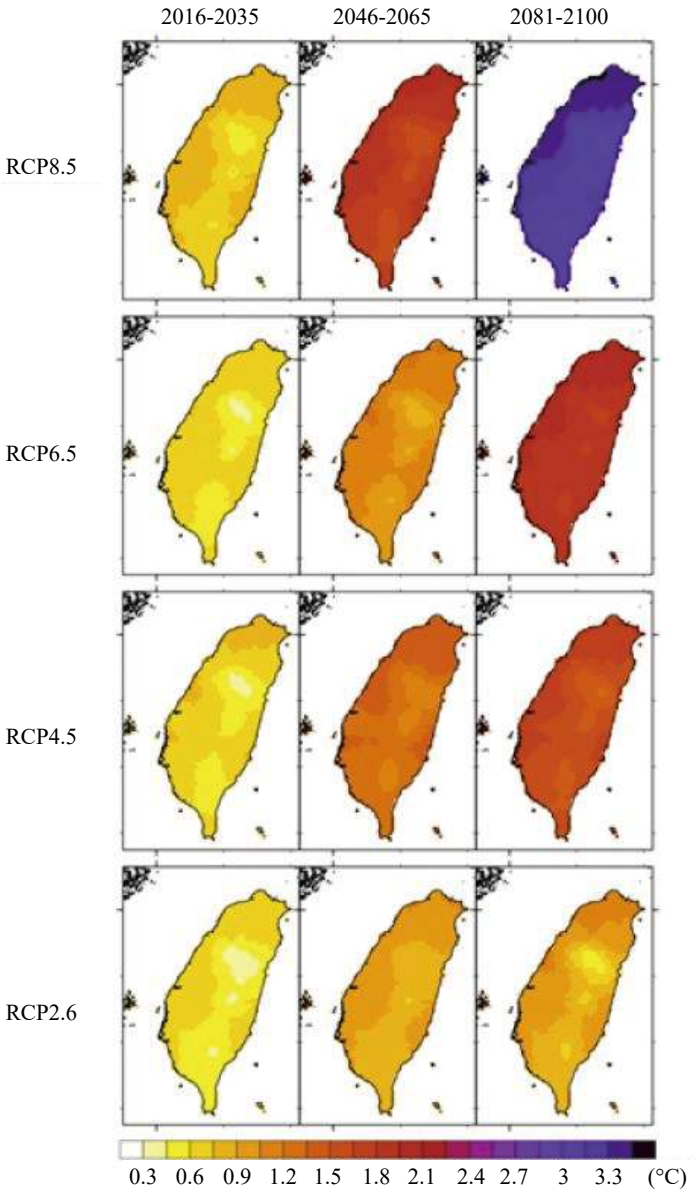


Figure 6.1.3 Near-surface mean temperature variations in Taiwan

Source: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

Table 6.1.1 Average temperature and centennial warming range in Taiwan

	Average temperature (centennial warming)	Daily maximum temperature (centennial warming)	Daily minimum temperature (centennial warming)
Annual	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: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

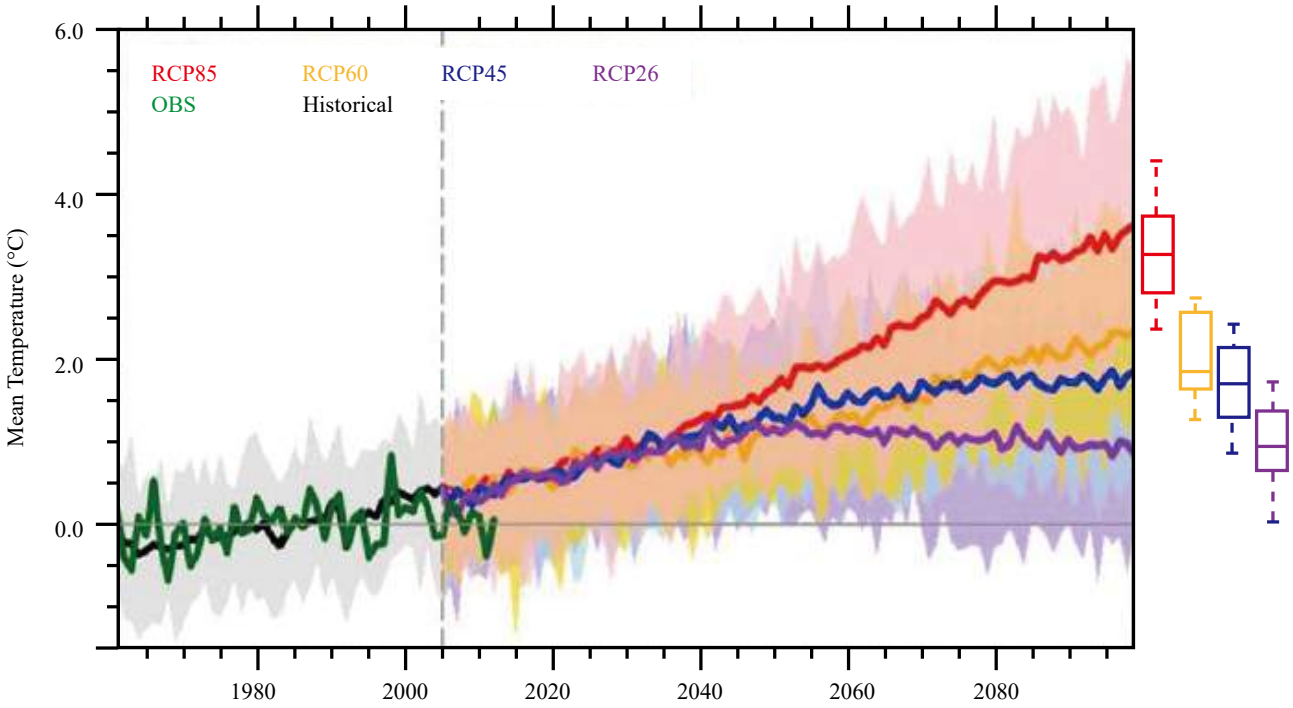


Figure 6.1.4 Average variation trend of time series of near-surface temperatures in Taiwan

Source: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

2) Estimation of rainfall variation trends and long-term rainfall trends

Using the TCCIP Taiwan Rainfall Index to describe the climate and rainfall changes in Taiwan, as shown in Figure 6.1.5, it is found that there was more rainfall in Taiwan from 1920 to 1960, less rainfall from 1960 to 1990, and a significant increase after the mid-1990s (especially after 2000). The decadal changes of the seasons were significant while there was a significant negative correlation between the autumn and spring rains. The decadal changes of the plum rain season (May and June) and the summer (July and August) were positively correlated with the changes in global average temperature after removing the long-term warming trend.

Under four different future scenarios, the annual average rainfall variation in Taiwan is estimated to deviate from the near future (2016-2035), mid-century (2046-2065) to the end of the century (2081-2100). Even though the degree of warming and the radiative forcing value vary with the situation and time course, as shown in Figure 6.1.6, there is no obvious systemic change pattern for the ensemble median of the annual mean rainfall change model. Although the average annual rainfall decreases in most scenarios in the near future, at the end of the century, the average shows the ensemble median of the model of the annual average rainfall change. Thus, there is no obvious systematic change pattern. The average annual rainfall increases. Generally speaking, the median of the change of the model ensemble is between - 5% and + 5%, and there is no significant trend of increase or decrease.

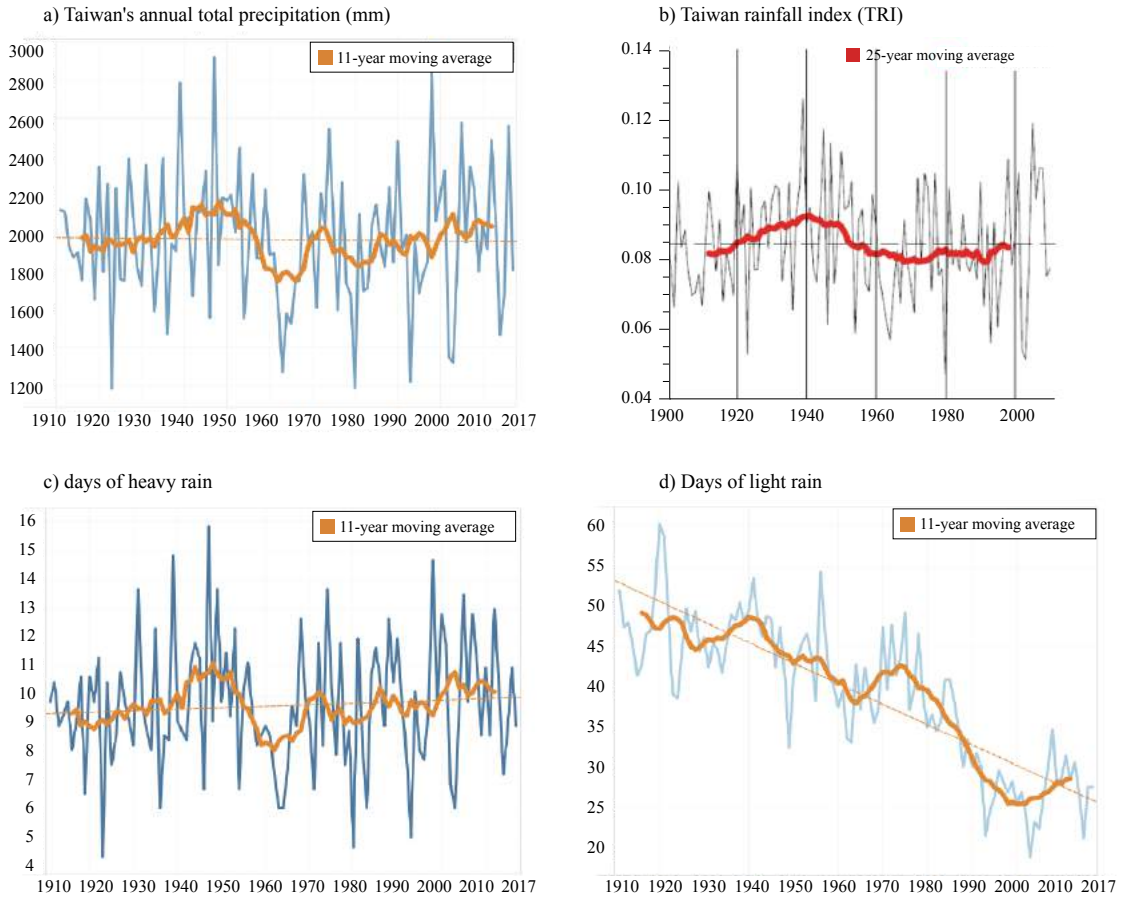


Figure 6.1.5 Rainfall trends in Taiwan

Source: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

By examining RCP 8.5, the future simulation scenario with the highest degree of warming as an example, the long-term rainfall trends over four seasons are analyzed, as exhibited in Figure 6.1.7. The thick black line refers to the average of 5km observations, the thick red line is the ensemble mean of the climate model, while the thin line is the result of the simulation and estimation of individual climate models. The bottom figure shows the anomalies of the four seasonal patterns relative to the current climate (1961-2005). The light solid line varies year by year, while the dark line is the average change of 11-year sliding. It is found that in the long run, the precipitation in Taiwan simulated and estimated by the CMIP5 climate model will increase most significantly in future summer, especially after the middle of the century. Autumn rainfall also tends to increase, but the increase is relatively small. Regional winter and spring rainfalls show a long-term downward trend, although the decrease range is smaller than that of increase in summer and autumn rainfall. However, because of precipitations over Taiwan's dry seasons of winter and spring being relatively small, there is little difference in percentage variation between different seasons. Similarly, although summer and autumn are typical wet seasons of rainfall in Taiwan (including plum and typhoon seasons), the rainfall is relatively abundant, but the simulation results between natural variations and models are more uncertain.

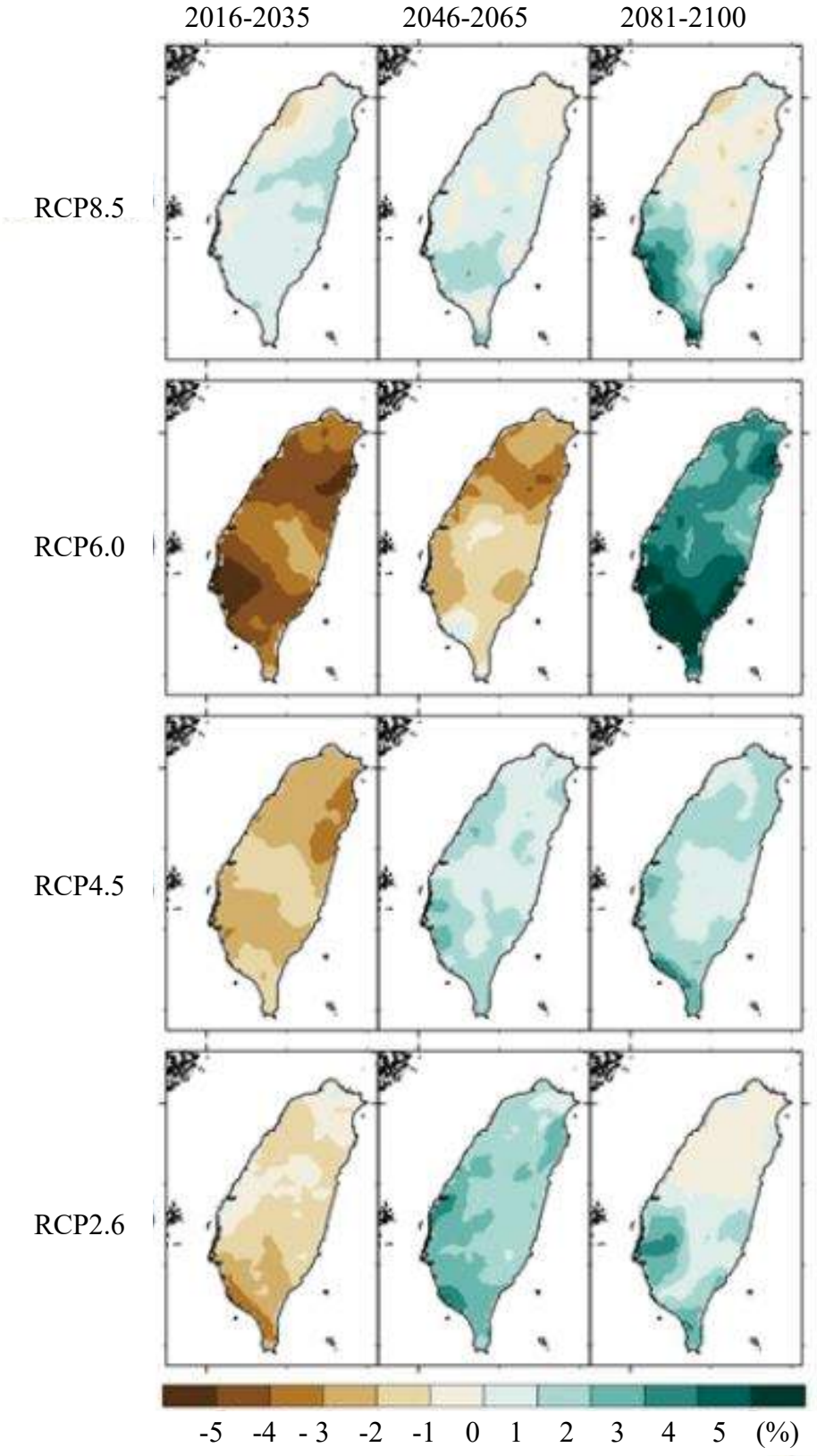


Figure 6.1.6 Estimation of average rainfall variation rates in Taiwan

Source: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

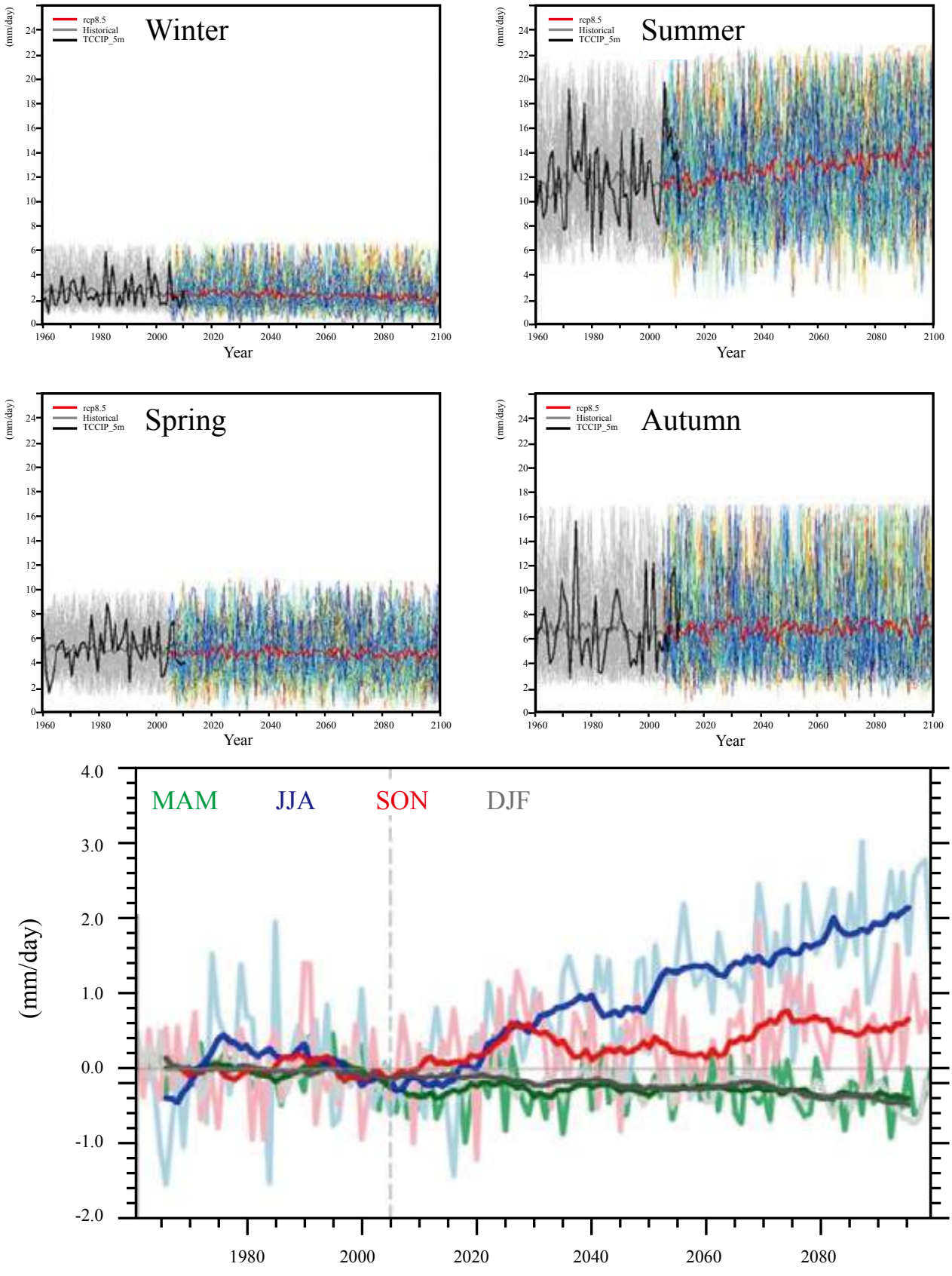


Figure 6.1.7 Time series of average four seasonal rainfall in Taiwan under the RCP 8.5 scenario

Source: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

3) Variation trend over seasonal days

In terms of temperature, the beginning date, length and peak value of each season in Taiwan had changed significantly in the past 60 years, as shown in Figure 6.1.8. With 1961 to 1990 as a base period, the summer length of Taipei, Taichung, and Hualien increased markedly from the 1970s, while that of Taitung did not increase until the 1980s. Except for Hengchun, which the change range was not significant, the increased range of each station was about five to six days every 10 years, and the largest increase was 8.4 days in every 10 years at Taichung Station, as shown in Table 6.1.2. Winter shows a downward trend in length. Although winter days in Hengchun were falling, there was no statistical significance. Other stations saw a drop at the rate of 5-8 days per 10 years, especially in Taipei with the fastest decrease in the number of winter days. The increase of summer days is caused by the advance of the start date of the season and the delay of the end date, while the decrease of winter days is caused by the delay of the start time and the advance of the end time, the date of the peak is delayed. The change of the length of winter and summer seasons changes the length of spring between winter and summer compressed and the seasons quickly.

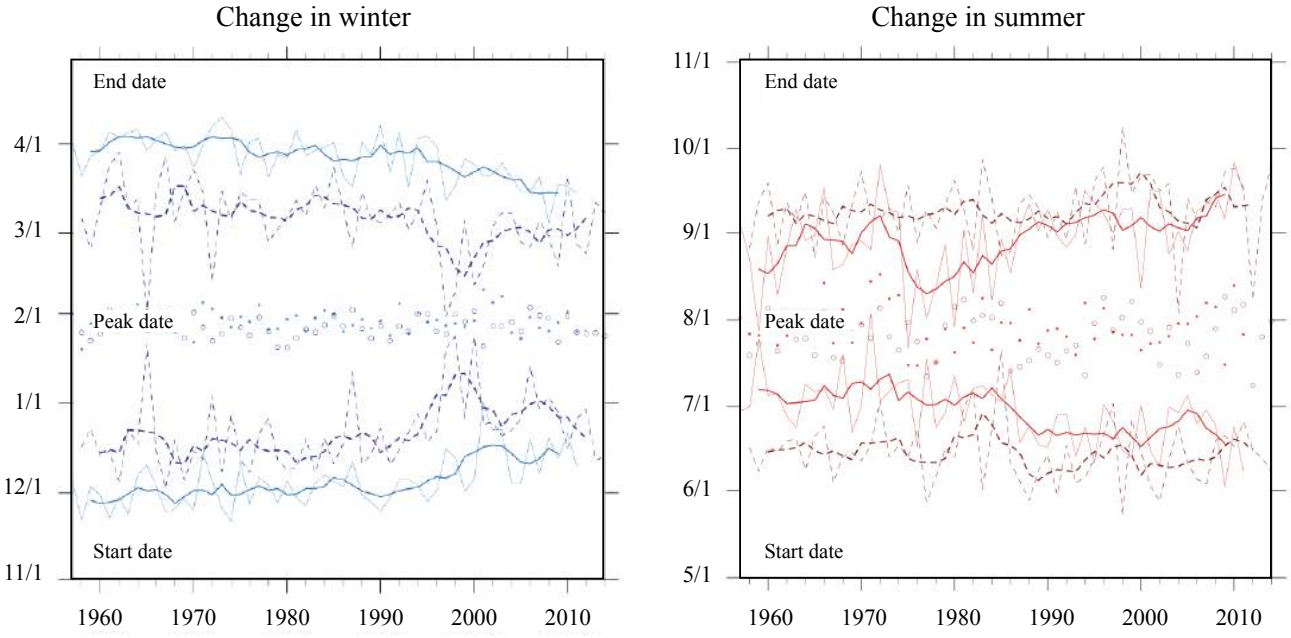


Figure 6.1.8 Seasonal trends in Taiwan

Source: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

Table 6.1.2 Summer and Winter Variations of Six Stations in Taiwan from 1957 to 2006

Seasonal variation in Taiwan		Taipei	Taichung	Tainan	Hengchun	Taitung	Hualien
Summer	Seasonal days	+6.47	+8.41	+5.95	+0.43	+6.33	+6.42
	Peak temperature	+2.48	+1.28	+1.12	+0.19	+1.01	+1.00
Winter	Seasonal days	-8.50	-7.54	-5.12	-2.62	-6.00	-6.62
	Peak temperature	+3.61	+3.74	+2.89	+1.14*	+2.19	2.78

Source: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

4) Extreme weather events

In terms of long-term variations of extreme weather events, warming is more evident at night than during the day. As shown in Figure 6.1.9, warm nights in Taiwan increased by almost 60 days over the 10 years, from 2001-2010, and as compared with those from 1911-1920. With the increase of warm nights, cold nights decreased significantly, but the decrease was slightly lower than the increase of warm nights.

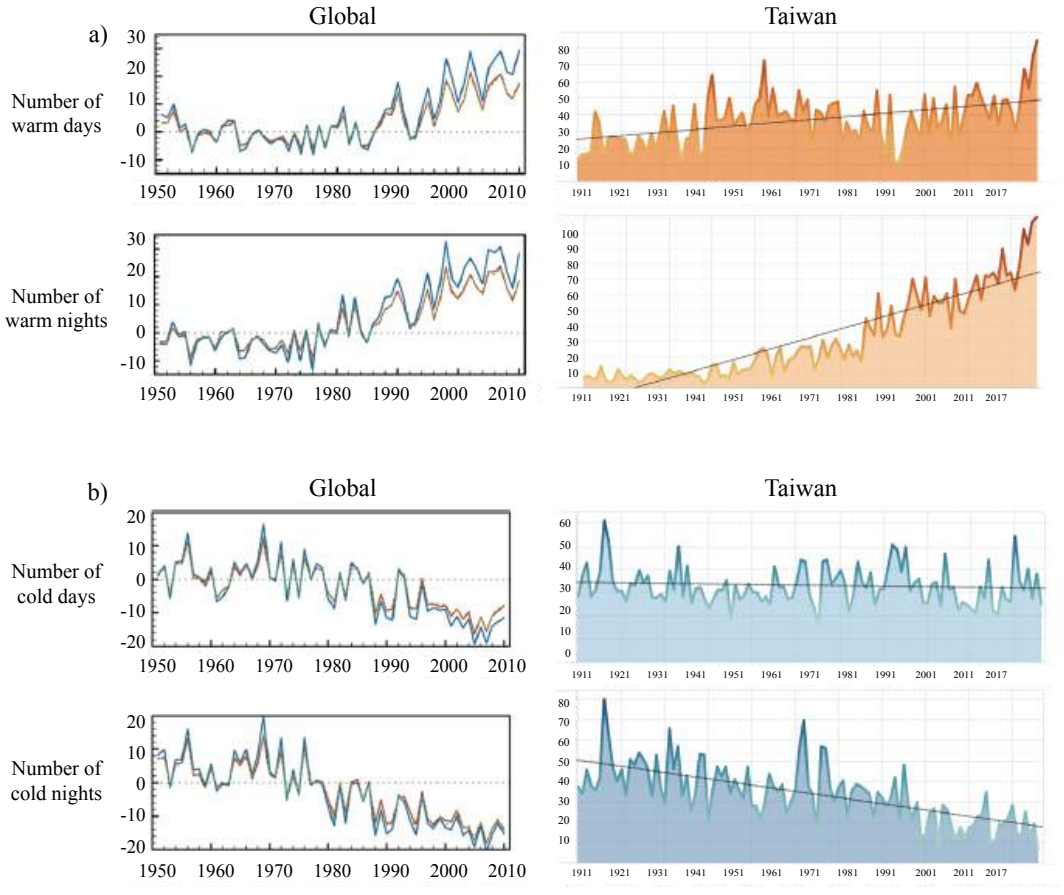


Figure 6.1.9 Trends in high and low temperatures day and night

Source: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

5) Typhoon

The number of typhoons affecting Taiwan was relatively large after the 1960s and 2000, averaging about 54 typhoons per 10 years, while the number was relatively small in the 1950s and 1970s and throughout 1990s, averaging about 40 typhoons per 10 years. On the whole, the number of typhoons invading Taiwan has an obvious decadal oscillation, and the long-term trend of increasing or decreasing is not obvious. The time series of the number of typhoons from 1950 to 2014 is presented in Figure 6.1.10.

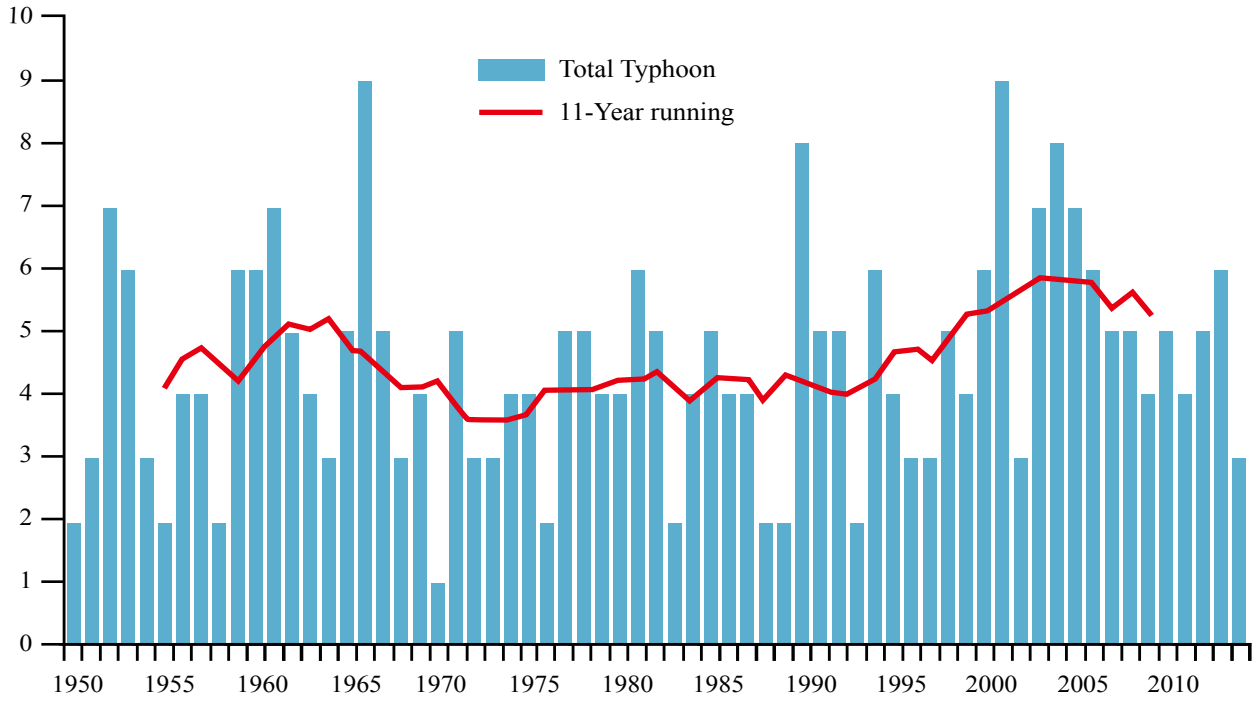


Figure 6.1.10 Time series of the number of typhoons that entered the coastline of Taiwan within 300km and stayed for 12 hours or more every year from 1950 to 2014

The red line represents the 11-year moving average, the X-axis represents the year, and the Y-axis represents the number of typhoons affecting Taiwan each year.

Source: National Science & Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017-Physical Phenomena and Mechanisms, 2017.

The number of mild typhoons was relatively small from the 1950s to 1960s. After the 1970s, the number remained stable, with no obvious long-term increasing or decreasing trend. The frequency of moderate typhoons was relatively low in the 1970s and 1990s, but remained relatively high in other periods; nonetheless the long-term change trend was not obvious. The number of strong typhoons increased from the 1950s to 1960s and after 1990s, with an average of 18 strong typhoons striking Taiwan every 10 years, but relatively few from the 1970s to 1980s, with an average of only seven ones affecting Taiwan every 10 years. From 1970 to 2010, the moving speed of typhoons invading Taiwan tended to slow down, and the time that affected Taiwan became longer. The slower the typhoon moves, the heavier will be the rainfall (95 percentile rank) it brings, which means that there will be more total rainfall during the typhoon's impact on Taiwan.

6) The trend in atmospheric composition change

In terms of atmospheric composition monitoring, the concentrations of carbon dioxide (CO_2) rose significantly between 1994 and 2013. Taking background monitoring stations, for example, the annual average concentrations of CO_2 at Lanyu, Yangmingshan, and Hengchun stations in 2004 were 375.4 ppm, 380.8 ppm and 370.1 ppm, respectively. In 2012, the figures were 393.4 ppm, 397.3 ppm and 397.5 ppm, respectively. CH_4 concentrations in Taiwan have a significant seasonal fluctuation, but there is no significant long-term change trend.

Since 1991, the CWB has had complete monitoring records of the total ozone at Taipei and Taitung (Chenggong) stations. The annual average of the total ozone at the two stations in 1993 was 259.2 DU and 255.8 DU, respectively, while that in 2017 was 270.5 DU and 264.8 DU, respectively. In recent years, the total ozone observed at Chenggong Station has increased slightly, but the observed at Taipei Station has not increased significantly.

The concentration of atmospheric aerosol PM10 also decreased year by year in the last 10 years (2004-2013). In 1994, the average concentration of PM10 in the air quality control regions ranged from 45.1μg m-3 to 89.8μg m-3; and ranged from 29.4μg m-3 to 70.9 μg m-3 in 2013.

7) Other

After the 1960s, the water vapor pressure and relative humidity showed a significant downward trend, but after 2000, the water vapor pressure did not change much. The changes in visibility and hours of sunshine also showed a significant downward trend after the 1960s, but the changes in sunshine hours did not change much after 2000.

6.2 Taiwan's adaption policy to climate change

Climate change has a comprehensive impact on human beings, and gradually poses varying degrees of unknown emerging risks at natural ecological, economic, social and political levels, which will also put Taiwan under the test to a severe degree. To cope with the risks and challenges caused by climate change, Taiwan also actively planned climate change adaptation work. In 2010, the National Development Council (NDC) invited experts from the industry and academia to set up a task force on "planning and promoting climate change adaptation policy guidelines and action programs," jointly developing a "National Climate Change Adaptation Policy Guideline" and constructing a framework for promoting the adaptation in Taiwan (Figure 6.2.1)

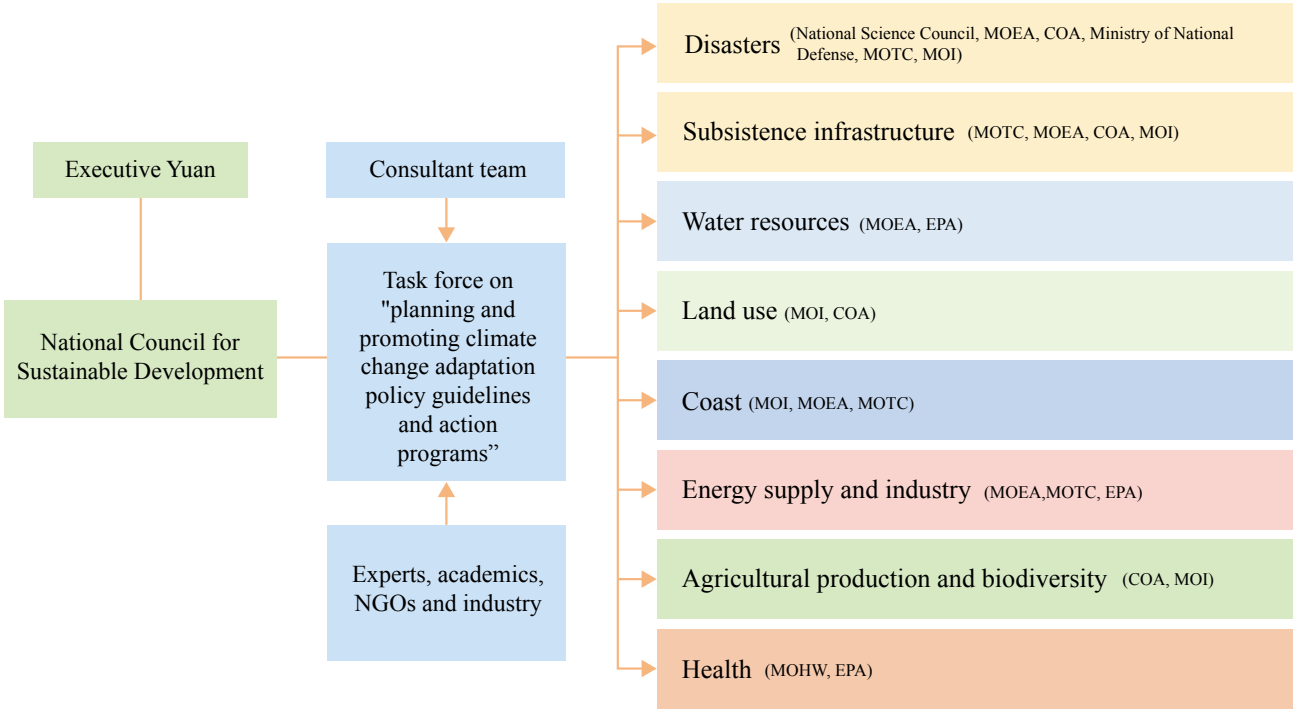


Figure 6.2.1 Taiwan's national climate change adaptation policy guideline and division of work in eight areas among the ministries

Source: National Development Council (NDC), National Climate Change Adaptation Policy Guidelines, 2012.

In reference to the future situation and research results of climate change in Taiwan discussed in the "Taiwan Climate Change Science Report 2011" published by the Ministry of Science and Technology (formerly the National Science Council under the Executive Yuan), as well as to the adaptation actions taken by various countries and the particularity and historical experience of Taiwan's environment, the National Climate Change Adaptation Policy Guidelines divided national adaptation into eight areas: disaster, subsistence infrastructure, water resources, land use, coast, energy supply and industry, agricultural production and biodiversity, and health, and set up working groups in various areas of adaptation under the task force to assist in planning and promoting adaptation-related work. The guidelines were approved by the Executive Yuan on June 25, 2012 while the adaptation strategy further translated into action. The Ministry of Science and Technology, the Ministry of Transportation and Communications, the Ministry of Economic Affairs, the Ministry of the Interior, the Council of Agriculture of the Executive Yuan, and the Ministry of Health and Welfare established eight adaptation working groups. In accordance with the framework of the policy guidelines, they formulated a complete plan of action for various areas of adaptation, proposing 399 action plans, which were integrated into 34 priority action plans by the NDC and completed the National Climate Change Adaptation Action Plan (2013-2017) as the main action of government departments to promote adaptation work for the actual implementation of policy guidelines.

In 2015, Taiwan passed the Greenhouse Gas Reduction and Management Act, specifying the nation's GHG reduction targets, promoting specific

actions in response to climate change, incorporating the division of labor among government agencies and promotion mechanisms, adhering to the spirit of both mitigation and adaptation, gradually improving the nation's adaptation to climate change, and striving to achieve its long-term GHG reduction targets, in order to ensure the country's sustainable development.

According to Article 13 of the Act and Article 11 of the Enforcement Rules thereof, the central industry competent authorities shall assess the vulnerability and impact in the jurisdictions vulnerable to climate change, formulate and promote relevant adaptation strategies, and regularly submit the results of the previous year's adaptation to the central authorities for collation every year. To facilitate the follow-up adaptation work, the EPA has convened two inter-ministerial consultation meetings, where relevant agencies were brought together to discuss issues such as national situation and risk assessment, adaptation plan schedule, division of labor among agencies, and information sharing.

6.3 Climate change adaptation strategies and actions

6.3.1 National Climate Change Action Guideline

To reduce and manage GHG emissions in addition to ensuring the sustainable development of the country, the Executive Yuan approved the National Climate Change Action Guideline on February 23, 2017, which lists 10 basic principles of climate change, six major policies on GHG mitigation and supporting and follow-up promotion mechanisms (see Figure 6.3.1). Through the national administrative programs on GHG emission control in energy, manufacturing, transportation, residential and commercial, agriculture and environment sectors, and the local governments' implementation programs on GHG control, horizontal and vertical integrations are carried out to effectively manage the reduction of GHG emissions from various sectors, and create common benefits for the sustainable development of the country and the maintenance of national security.

The policy guidelines cover

1. Adaptation: eight areas of adaptation in the national climate change adaptation policy guidelines, and the Paris agreement and the 2030 sustainable development goals (SDGs) adaptation strategies.

2. Mitigation: the environment sector, with the strategy compatible with international and foreign promotion directions, in addition to the five major sectors as set forth in Article 9 of the Act.

3. Supporting policy: in response to international trends, the action guidelines also cover increasingly important issues such as green finance, carbon pricing, and resilience building.

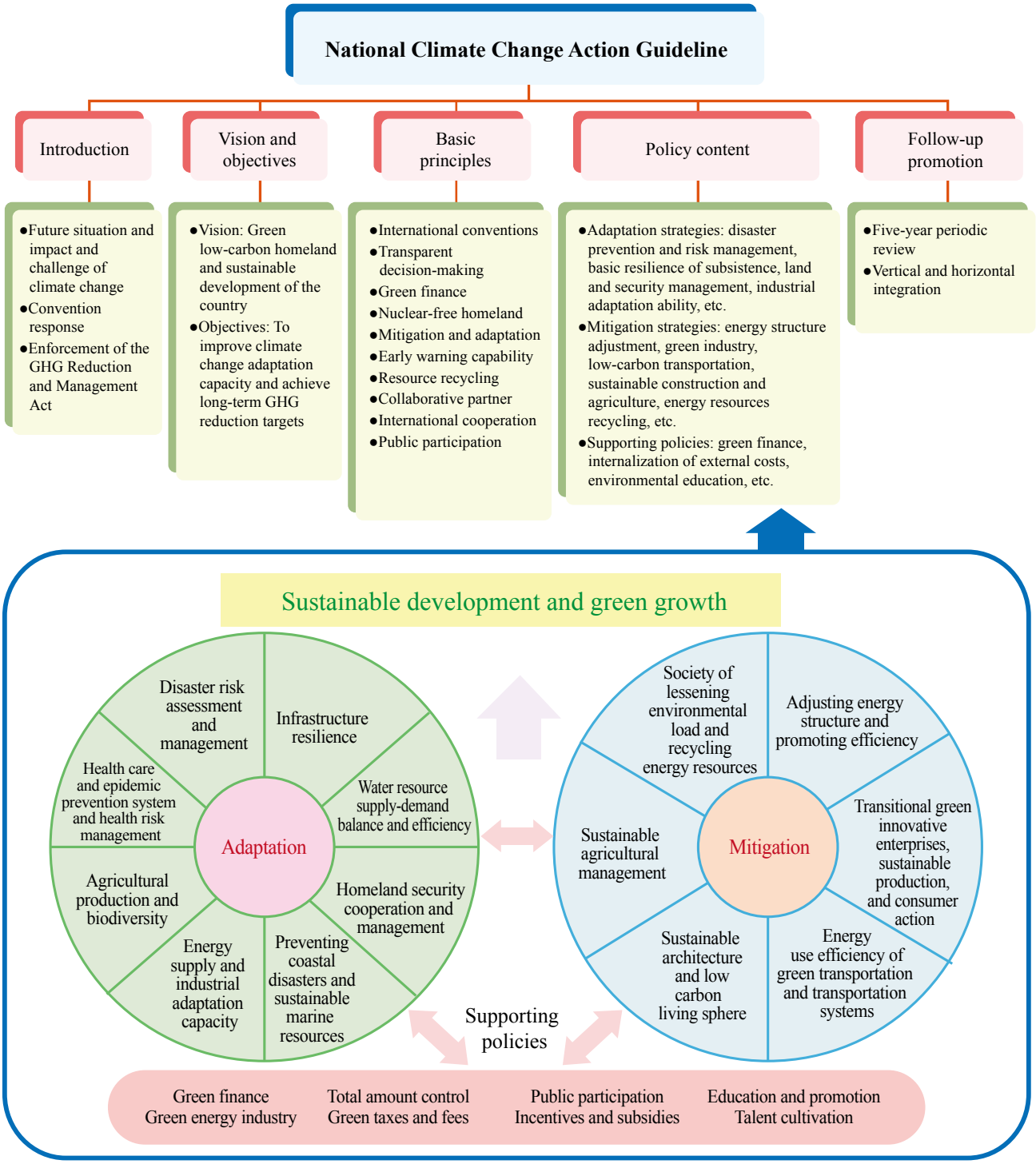


Figure 6.3.1 Policy Content of Climate Change Adaptation under the Framework of National Climate Change Action Guideline

Source: Executive Yuan Environmental Protection Administration

6.3.2 National Climate Change Adaptation Policy Guidelines

To enhance the national adaptation capacity, reduce social vulnerability, and establish an integrated operational mechanism in the nation, as the basis for the policy framework and plan promotion, the NDC actively promoted climate change adaptation. On January 29, 2010, the NDC formed a task force on "planning and promoting climate change adaptation policy guidelines and action programs," and formulated the "National Climate Change Adaptation Policy Guidelines approved by the Executive Yuan on June 25, 2012.

In addition to analyzing Taiwan's climate change and future estimates, and formulating policy vision, principles and objectives, the policy guidelines, by referring to the adaptation actions taken by various countries in the world and taking into account the particularity and historical experience of Taiwan's environment, divided national adaptation into eight areas: disaster, subsistence infrastructure, water resources, land use, coast, energy supply and industry, agricultural production and biodiversity, and health, elaborating on the impacts and challenges of climate change on various fields, and planning the vision and strategies for promoting adaptation in Taiwan (Table 6.3.1).

Table 6.3.1 Overall impacts and challenges facing Taiwan in the future as collated by the National Climate Change Adaptation Policy Guidelines

National Climate Change Adaptation Policy Guidelines		
Overall impacts	Challenges	Adaptation strategies
1. Rising temperatures 2. Rainfall pattern change 3. Increased intensity and frequency of extreme weather events 4. Sea level rise	Drought, heat wave, rainstorm, storm tide, landslide, typhoon, ecological change, land use and land cover change, land subsidence, seawater intrusion, air deterioration, water quality change	Vision: to construct a sustainable Taiwan that can adapt to climate risks. Adaptation strategies: 1. Implementing national spatial planning and management. 2. Strengthening the capacity of natural, social and economic systems for disaster prevention and avoidance. 3. Promoting comprehensive river basin management. 4. Giving priority to high-risk areas of climate change. 5. Improving the ability of adaptation and protection in metropolitan areas.

Source: National Development Council (NDC), National Climate Change Adaptation Policy Guidelines, 2012.

6.3.3 National Climate Change Adaptation Action Plan (2013-2017)

To further translate adaptation strategies into actions, the NDC and relevant ministries jointly developed the National Climate Change Adaptation Action Program (2013-2017) under the framework of the policy guideline, which was then approved by the Executive Yuan on May 22, 2014, and under the program, promoted the overall adaptation plan with emphasis on the construction of adaptation capacity. Through the formulation of structural climate change laws and organizational authority and responsibility, developing climate change scientific research and analysis capacity, strengthening environmental monitoring technology and information systems, vulnerability assessment and climate change governance, education and publicity, the nation's adaptation capacity has thus been reinforced. The results of the implementation are summarized as follows:

1. Overall adaptation plan implementation outcomes in 2013-2017

Under the framework of the National Climate Change Adaptation Policy Guideline, the overall adaptation plan focused on the construction of adaptation capacity, and strengthened the nation's adaptation capacity by formulating structural climate change laws and organizational authority and responsibility, climate change scientific research and analysis capacity, strengthening environmental monitoring technology and information systems, vulnerability assessment and climate change governance, education and publicity (as shown in Table 6.3.2). The implementation is described as follows:

1) Constructing the quality basis of climate change adaptation

(1) Developing a legal system for climate change

Climate change is highly uncertain, interdisciplinary and inter-ministerial. To promote the campaign in a long-term and sustained way, Taiwan promulgated the "Greenhouse Gas Reduction and Management Act" in 2015 and related sub-laws as the nation's first legislation to deal with climate change. In the meantime, founded by the GHG management fund, Taiwan has drawn up the "Regulations for the Preservation and Use of the Income and Expenditure of the Greenhouse Gas Management Fund," which is dedicated to the adaptation to climate change and GHG reduction, so as to enable the implementation of relevant actions in response to climate change.

(2) Planning and establishment of organizational authority and responsibility for climate change

Before the promulgation of the Greenhouse Gas Reduction and Management Act, the NDC set up an interdisciplinary advisory team, where relevant ministries, experts and scholars, NGO and industry representatives were brought in to found a task force on "planning and promoting climate change adaptation policy guidelines and action plans," responsible for the operation of climate change organizations and the development of policy guidelines and action plans, as an important platform for monitoring and promoting climate change adaptation.

Following the promulgation of the Greenhouse Gas Reduction and Management Act, the provisions established the organizational power and responsibility for climate change in Taiwan. The central competent authority is the Environmental Protection Administration (EPA), with the powers and responsibilities divided among relevant government agencies and the Executive Yuan incorporating relevant central authorities, civil organizations and experts and academics to develop and review the division, integration, promotion of climate change adaptation and GHG reduction, and collate achievements. In the future, the overall promotion will be actively handled in accordance with the powers and responsibilities stipulated thereunder, emphasizing the integration of intergovernmental and inter-ministerial operations, the central and local layered responsibility for the promotion and the establishment of partnerships to jointly carry out the adaptation work.

(3) Establishing economic and financial planning in response to climate change

The scale and probability of future extreme climate events are highly uncertain. Additionally, climate change adaptation is a long-term task. At present, the ministries continuously arrange and prioritize financial resources using a zero-basis budgeting system. To maintain fiscal stability and sustainable development of the country, the Ministry of Finance uses various policy tools to diversify its financial resources to respond to major national emergencies, and to strengthen its ability for adaptation to climate change, taking measures to promote financial soundness and strengthening the foundation of finance. The Ministry of Finance also diversifies financial resources to support comprehensive treatment of river basins, provide tax benefits to build a sustainable environment and propose an energy tax to be implemented in due course.

Table 6.3.2 Overall adaptation plan promotion focuses under the National Climate Adaptation Action Program for 2013-2017

Emphases
1) Building a quality foundation for climate change adaptation
1. Developing a legal system for climate change • The Greenhouse Gas Reduction and Management Act was promulgated on July 1, 2015. • The National Climate Change Action Guideline was approved by the Executive Yuan on February 23, 2017.
2.Planning and establishment of climate change organizational powers and responsibilities • Established in Article 2 thereof
3. Establishing economic and financial planning in response to climate change • Taking measures to promote financial soundness
4. Enhancing the capacity of adaptation to climate change, strengthening the prowess in scientific research and initiating the three major programs: • Consortium for Climate Change Study (CCliCS): establishing Taiwan's local climate change model and introducing the US' high-resolution model. • Taiwan Climate Change Projection and Information Platform (TCCIP): building climate change databases, providing climate change projection downscaling data, and providing climate change scientific data services. • Taiwan Integrated Research Program on Climate Change Adaptation Technology (TaiCCAT): building vulnerability and interdisciplinary assessment tools, risk assessment and adaptation processes.
5. Promoting local climate change adaptation programs • Developing operational procedures for the planning of local climate change adaptation programs. • Subsidizing local governments in stages to promote local adaptation programs.
6. Strengthening public participation and communication ability in climate change • Promoting the establishment of an information platform for climate change adaptation. • Organizing creative publicity and promotion activities on climate change adaptation. • Launching national climate change adaptation education programs.
2) Assessing climate change risks and adaptation planning
1. Promoting the implementation of climate change risk assessment • Developing "Taiwan Climate Change Science Report 2017."
2. Rolling review of national climate change adaptation policy guidelines and action plans
3) Promoting adaptation programs in high-risk areas
1. Giving priority to promoting climate change adaptation plans and planning processes in the northern metropolitan area
2. Continuing to promote adaptation programs in other high-risk areas

Source: National Development Council (NDC), National Climate Change Adaptation Action Program 2013-2017 Implementation Achievements Report, 2018.

(4) Enhance climate change adaptation ability

To strengthen the research prowess in climate change and develop the tools of climate change adaptation analysis and planning, the Ministry of Science and Technology, the Academia Sinica Research Center for Environmental Changes, the National Science & Technology Center for Disaster Reduction, and other units have actively promoted climate change projection, assessment, planning and development, and related scientific research work, so as to foster the nation's capability to establish independent climate change simulation models. Further, to accelerate the production and application of climate science data and the development and promotion of adaptation tools, they launched three research programs, namely, the CCliCS, TCCIP and TaiCCAT, to lay a solid foundation for future climate science research in Taiwan.

Among them, the Taiwan Integrated Research Program on Climate Change Adaptation Technology (TaiCCAT) explores into environmental system analysis, interdisciplinary vulnerability assessment and adaptation governance from the perspective of scientific research and interdisciplinary integration, thus drawing conclusion on the direction of the development of adaptation technology and policy recommendations. The program transformed the impact of climate change into a new opportunity for research and national development, and has also developed the TaiCCAT decision support system, a tool for climate change adaptation analysis and planning, to effectively integrate resources and support climate change adaptation decision-making, thereby to enhance the capacity of adaptation and construction and boost the prowess of scientific research.

To improve the ability of short-term climate change prediction, the CWB has refined the specific work items of current climate prediction models, boosted the resolution of global atmospheric circulation models, established the ocean-atmosphere coupled climate forecasting system, developed statistical and dynamic downscaling, and enhanced the resolution of atmosphere-ocean models. The agency has also strengthened the development of the application value of the model and provided products for forecasting the development trend of climate models in weather systems such as drought, extreme rainfall, cold winter, spring rain, high temperatures and typhoon, thereby to enhance the overall forecast ability of the government to respond to climate change, promote the interdisciplinary application services of meteorological information, and hold forums on the application of meteorological information, including the themes of agriculture, public health and fisheries to understand the needs of meteorological applications in various fields to strengthen meteorological services.

To improve the ability to project long-term climate change, the CWB is dedicated to developing meteorological observation technology, scientific and technological research, forecasting services, and other fields. CWB provides basic historical climatic data on climate change in Taiwan,

estimates of future rainfall patterns across the nation, large-scale circulation index of extreme rainfall in the plum rain season nationwide, and develops analysis and projection techniques of domestic climate change, estimates the probability of extreme weather occurrence in the country, supports the government in disaster prevention infrastructure and other fields, establishes risk management mechanisms for climate disasters, and assists relevant fields in establishing risk management mechanisms for climate disasters.

Four future climate simulation scenarios have been completed, including monthly average data of nine atmospheric field variables and one oceanic field variable, daily climatic data, in addition to summer and winter sea temperature, average temperature and extreme temperature, rainfall, annual rainfall patterns, and future change projections of large-scale climate indicators. Information for projecting the development trend of climate change-related variations can be used as a reference for decision-making on climate disaster impact and adaptation in relevant fields and lay an important foundation for climate change adaptation in Taiwan.

(5) Cultivating Specialists and Generalists with Climate Change Adaptation Education

As climate change adaptation is a new concept and has interdisciplinary characteristics, Taiwan has actively cultivated interdisciplinary climate change professionals. In terms of talent cultivation, the Ministry of Education has actively advocated the "Climate Change Adaptation Talents Training Program" since 2012, with the intention to nurture climate change adaptation talents through the dual strategy of training generalists and specialists. Given that the concept of climate change requires more background knowledge, the generalist nurturing strategy has gradually introduced the concept into elementary to high school in order of difficulty, while in college, the general education curriculum and credit programs lay the foundation for college students' general literacy in climate change. The specialist cultivation strategy, on the other hand, has incorporated the concept of climate change into professional courses, coupled with the mode of industry-university cooperation, and cultivated industrial experts and senior talents to meet the needs of future industrial development (the structure is shown in Figure 6.3.2).

To effectively integrate resources, the Ministry of Education has consolidated the disaster prevention education and climate change adaptation talents training programs since 2015, to constantly promote "School Disaster Prevention and Mitigation and Climate Change Adaptation Education Refinement Projects." During the promotion period, the ministry completed 48 supplementary textbooks and teachers' manuals on climate change adaptation for primary and secondary schools, 16 core textbooks and professional modules on climate change adaptation for general education courses in colleges and universities, and 18 practical and supplementary textbooks on the integration of climate change adaptation specialties in colleges and universities.

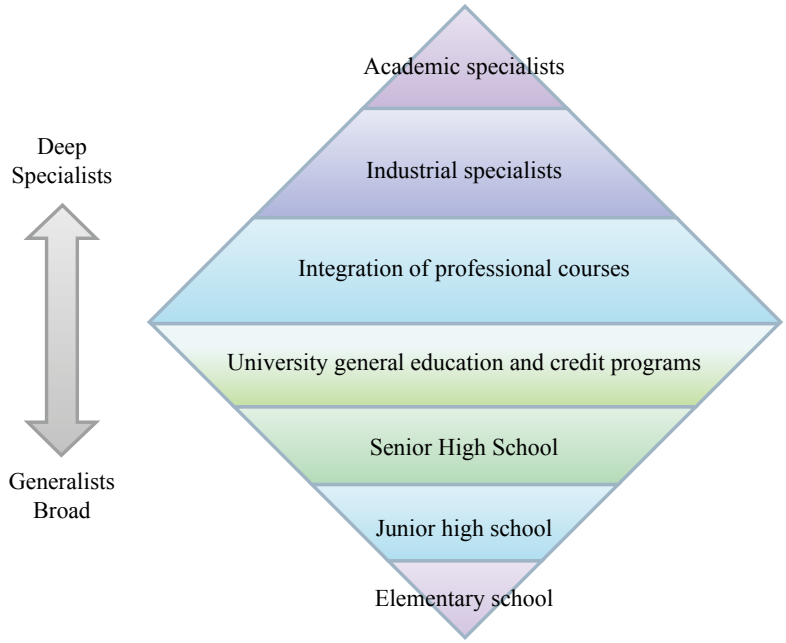


Figure 6.3.2 Framework for Cultivating Specialists and Generalists under the Ministry of Education's Climate Change Adaptation Education

Source: National Development Council (NDC), National Climate Change Adaptation Action Program 2013-2017 Implementation Achievements Report, 2018.

(4) Promoting and Funding Local Climate Change Adaptation Plans

The adaptation strategy and measures were implemented from the central to the local level in response to the concept of global thinking and local action. The nation promoted local climate change adaptation plans by providing subsidies in stages to municipal and county/city governments to develop "local climate change adaptation programs," and in 2012 selected Taipei City and Pingtung County, two regions with different geographical, social and economic activities, to conduct a pilot operation of the local climate change adaptation demonstration project. The planning process emphasized the establishment of an interagency promotion platform, inviting relevant stakeholders to forge partnerships, and reach a consensus through multiple discussions. Moreover, based on the experience of the two counties and municipalities, the "Guidelines for Planning Operations of Local Climate Change Adaptation Plans" were completed, introducing step by step the international trends of climate change and the direction of national policies, operating procedures for adaptation and planning, the structure of the promotion organizations, and promotion methods, so that local government staff responsible for adaptation planning business and professional planning teams would establish more understanding of relevant "adaptation" concepts and strategic planning procedures, which could be used as a reference for the follow-up promotion by local governments, as shown in Figure 6.3.3.

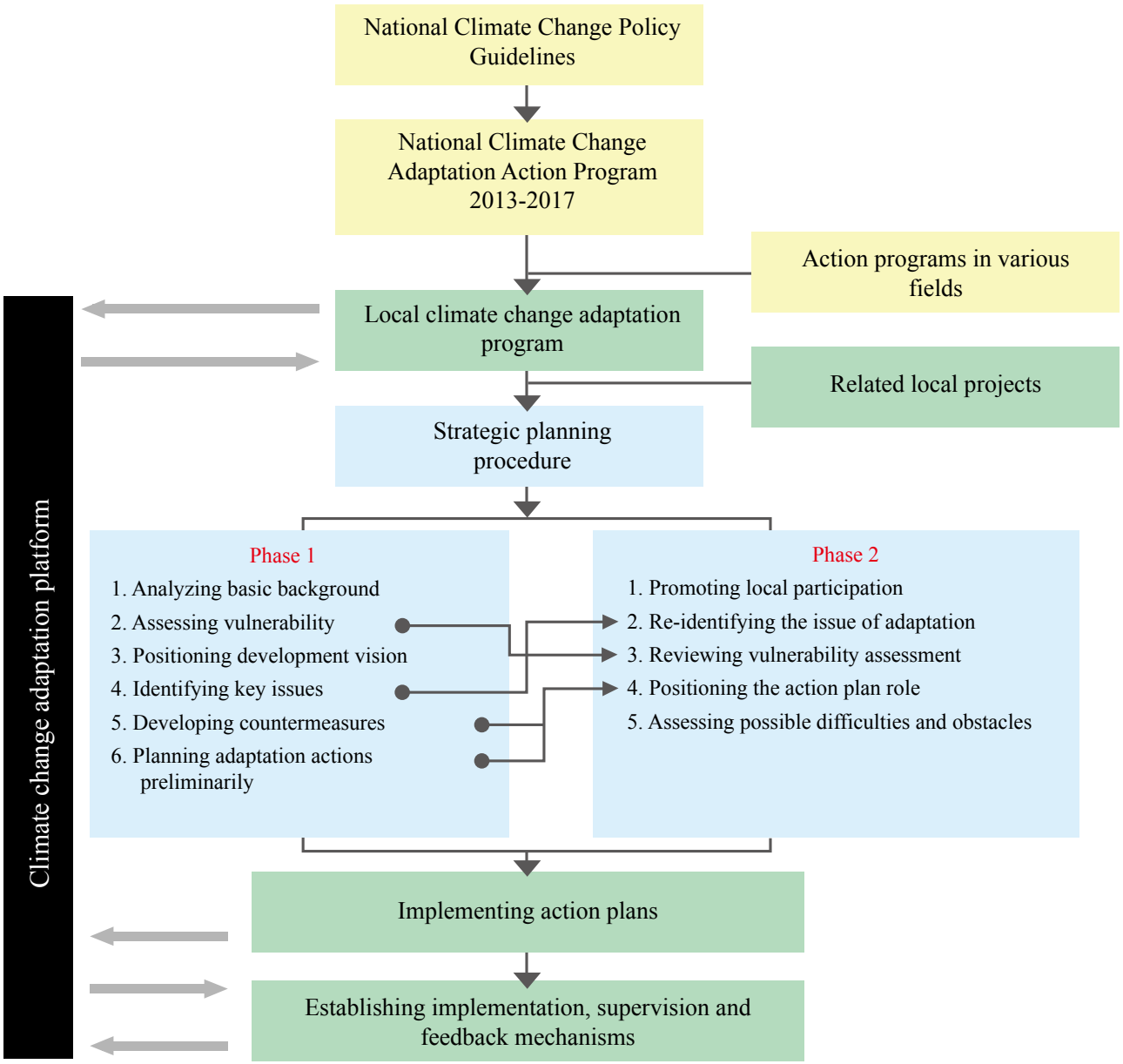


Figure 6.3.3 Operational procedures for the planning of local climate change adaptation plans

Source: National Development Council (NDC), National Climate Change Adaptation Action Program 2013-2017 Implementation Achievements Report, 2018.

2) Assessing climate change risks and adaptation planning

To assess the risk of climate change, the estaTo assess the risk of climate change, the establishment of a climate change risk assessment mechanism will help assess the climate risk which Taiwan may confront. In the future, under the framework of the GHG Reduction and Management Act and its Enforcement Rules, as well as the basic principles of the National Climate Change Adaptation Action Guideline, it is necessary to continuously strengthen the scientific basis for assessing the vulnerability and impact of climate change in order to formulate and promote relevant adaptation strategies and enhance adaptation to climate change.

The National Science and Technology Center for Disaster Reduction (NCDR) has been carrying out climate change risk assessment research and reports through a long-term plan (see Figure 6.3.4 for the connections between research institutions). Important achievements included the development of basin-wide disaster impact methods and disaster damage assessment tools, the completion of disaster risk maps projected based on climate change, the production of dynamic downscaling data for extreme events and disaster application assessment, the promotion of the MOST integrated climate change project, the publication of Taiwan's climate change scientific reports for 2011 and 2017, the release of climate change disaster risk assessment reports, and the implementation of the NDC's "Climate Change Adaptation Policy Guidelines and Action Programs in the Field of Disasters," and other projects (see Table 6.3.3 for key achievements over the years).

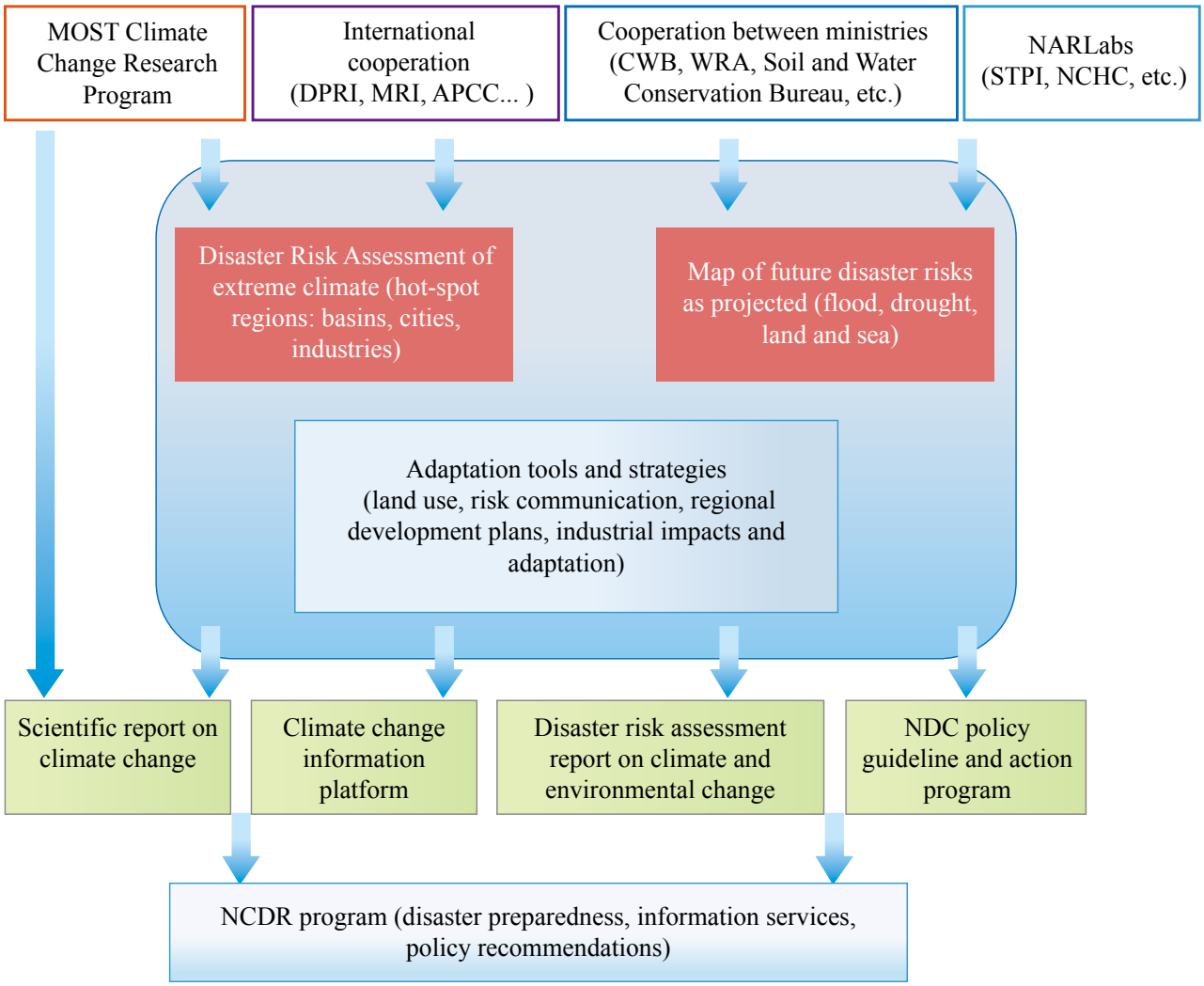


Figure 6.3.4 Connections between research institutions on NCDR extreme climate adaptation

Source: National Development Council (NDC), National Climate Change Adaptation Action Program 2013-2017 Implementation Achievements Report, 2018.

3) Promoting adaptation programs in high-risk areas

In view of the interdisciplinary, inter-sectoral and highly uncertain nature of climate change, it is necessary to integrate inter-sectoral programs, consider the vulnerability of the overall environment and the difficulty of restoration according to the overall adaptation strategy outlined in the policy guideline, and give priority to high-risk areas in order to reduce the impact of climate change on the loss of life and property. For this reason, the nation chose northern metropolitan areas (Keelung, Taipei, New Taipei, and Taoyuan) as demonstration cases to give priority to climate change adaptation programs.

Table 6.3.3 NCDR key achievements in climate change risk assessment over the years

Year	Achievements
2008	Translating and publishing the Summary for Policymakers in the 4th edition of IPCC Climate Change Assessment Report (AR4)
2009	Planning and promoting the first phase of the National Science Council "Taiwan Climate Change Projection and Information Platform Construction Project" (TCCIP-I)
2010	Producing climate change hazard risk maps (current status)
2011	Publishing "Taiwan Climate Change Science Report 2011"
2012	Formulating climate change adaptation policy guidelines and action plans in the field of disasters
2013	Translating and publishing IPCC SREX (Disaster Risk Assessment Report)
2013	Translating and publishing the Summary for Policymakers in the 5th edition of IPCC Climate Change Assessment Report (AR5)
2013	Starting the second phase of the MOST "Taiwan Climate Change Projection and Information Platform Construction Project" (TCCIP-II)
2014	Producing a national disaster risk map as projected by future climate change
2015	Establishing drought monitoring and early warning platforms and projecting short-term seasonal flow
2015	Producing a local disaster risk map as projected by future climate change
2016	Climate change disaster risk atlas and Q&A
2017	Promoting the new phase of the MOST project "Taiwan Climate Change Projection Information and Adaptation Knowledge Platform"
2017	Publishing "Taiwan Climate Change Science Report 2017 Volume 1 Physical Phenomena and Mechanisms" and "Taiwan Climate Change Science Report 2017 Volume 2 Impact and Adaptation Orientation"

Source: National Development Council (NDC), National Climate Change Adaptation Action Program 2013-2017 Implementation Achievements Report, 2018.

The planning process followed the six steps of the TaiCCAT decision support system. In reference to the analysis contents and periodic results of Taiwan's climate change risk assessment and related assessment reports, the vulnerability analysis and risk assessment of climate change in the region were completed. In addition, a comprehensive review of national and local adaptation action plans related to the region was conducted to develop rolling adjustment recommendations. The overall process of promoting the development of the "climate change adaptation plan for the northern metropolitan area" was completed through several interdisciplinary work meetings, group meetings, citizen cafes, questionnaire surveys and other forms of participation, and through interactive communication and discussion to reach a consensus.

The program proposed adaptation targets to "reduce exposure to climate change risks" and to "grasp the opportunities for climate change adaptation." In the long run, the program aimed to "co-exist with climate change risks," and then develop the adaptation issues, strategies and action plans based on the overall analysis results. To integrate resources from all dimensions, three main regions for adaptation are defined: metropolitan areas, river basins and coastal areas, among which the metropolitan areas need to pay attention to the impact of increased rainstorm on densely populated urban areas; river-basin areas mainly focus on the overall allocation of water resources, as well as slope disasters and resource conservation in Shimen Reservoir and its catchment areas; coastal areas center on land use in coastal flood-prone areas and its impact on biological habitats. Corresponding highlight plans have been developed according to the three adaptation regions as priorities for follow-up implementation.

2. Key implementation achievements in various adaptation areas in 2013-2017

1) Disaster

To reduce the risk of disasters caused by climate change, the MOST and the NCDR have promoted disaster risk assessment, as well as comprehensive adaptation policies and action plans. Through the investigation and assessment of disaster risks, the research and development of disaster risk maps, the construction of infrastructure capacity and the implementation of disaster prevention and adaptation measures, the mechanism of reducing the risk of climate disasters has been gradually built to strengthen the overall adaptability to disaster prevention and avoidance (see Figure 6.3.5 for the key implementation results).

Disaster Risk Survey and Assessment	●Geological sensitive area, disaster-prone area investigation, risk of energy supply facilities ●Central Geological Survey, Forestry Bureau, Bureau of Energy
R&D of Disaster Risk Map Data	●Developing disaster risk maps, flooding potential maps and vulnerability maps ●WRA, NCDR
Infrastructure Capacity Building	●Establishment of basic data, scientific research, establishment of monitoring and forecasting systems, back-up systems center, talent cultivation, teaching material R&D, education and promotion ●CWB, MOST, WRA, Soil and Water Conservation Bureau, National Fire Agency, Ministry of Education
Implementation of Disaster Prevention and Adaptation Measures	●Breakwater maintenance, urban flood mitigation technology, low impact development technology, water quality improvement, forest conservation, park response mechanism, business plan amendment, bridge safety ●Taiwan International Ports Corporation, Architecture and Building Research Institute, Construction and Planning Agency, Water Resource Bureau, EPA, Council of Indigenous Peoples, Science Park Administration, Civil Aeronautics Administration, Directorate General of Highways

Figure 6.3.5 Key implementation achievements of action programs in the field of disasters

Source: National Development Council (NDC), National Climate Change Adaptation Action Program 2013-2017 Implementation Achievements Report, 2018.

2) Infrastructure

To improve the adaptability of subsistence infrastructure to climate change, Taiwan has established a risk assessment method and information for climate change of railway and highway systems in the transportation system, reviewed relevant design criteria for climate change risk factors, continuously strengthened the slope management system of railways and highways, and developed strategies to reinforce facilities toughness and enhance the adaptability. With regards to water supply and water resources systems, the framework and process of climate change impact assessment were established to assess the carrying capacity and water shortage risk of regional water resources, to complete the water resources risk maps of Northern, Central, Southern and Eastern Taiwan, and the renovation and improvement of farmland water conservancy facilities, in order to boost the efficiency of agricultural irrigation water use. Regarding energy supply systems, the impact of extreme weather such as heavy rainfall and typhoons on reservoirs, dams, natural gas pipelines, power transmission and distribution systems has been assessed to establish a risk matrix for risk assessment and adaptation guidance for the energy industry.

3) Water resources

Under the impact of climate change, the Water Resources Agency (WRA) working on the guiding principle of sustainable management and utilization of water resources has pursued various adaptation strategies, actions and frameworks to ensure a balanced supply and demand of water resources , as shown in Figure 6.3.6.

Through water resources development and conservation, water resources risk maps of Northern, Central, Southern and Eastern Taiwan and outlying islands were completed, high-risk reservoirs and water shortage risks of counties and cities were assessed, water resources strengthening strategies were formulated, surface hydrological and offshore hydrological observation and monitoring data were continuously updated. With respect to water resources supply, the Reclaimed Water Resources Development Act (Draft) were promulgated in 2015 to establish a domestic legal framework for the recovery and reuse of waste (polluted) water or effluent, , in order to promote water conservation- a special chapter on water conservation was added to the Water Supply Act in 2016. Moreover, low impact development and reservoir dredging operations were conducted on a trial basis in the reservoir storage or catchment area at the level of technical research and development, while water right information networks were completed and water right and water use scope management systems were integrated. For water demand, through the sustainable water price decision-making and evaluation model, the possible evolution of water price decision-making under the current environment was simulated, and the water price strategy suitable for the sustainable development of domestic water supply enterprises was developed. The basic rainwater storage technology was developed and incorporated into the technical specifications for rainwater storage and utilization design of buildings, and a promotion workshop on recirculating aquaculture technology was held to encourage the transformation into a low-consumption aquaculture industry. In terms of water resources import and export strategies, the estimation results of national virtual water use and water footprints, as well as the blue water footprints of northern, central, southern and eastern districts of Taiwan and the virtual water flow between the regions were completed. The Handbook for the Inventory and Research of Water Footprints of Manufacturing Products and the Handbook for the Inventory and

Research of Water Footprints of Service Industry Services were compiled, and the inventory and guidance of water footprints of manufacturing and service industries were promoted.

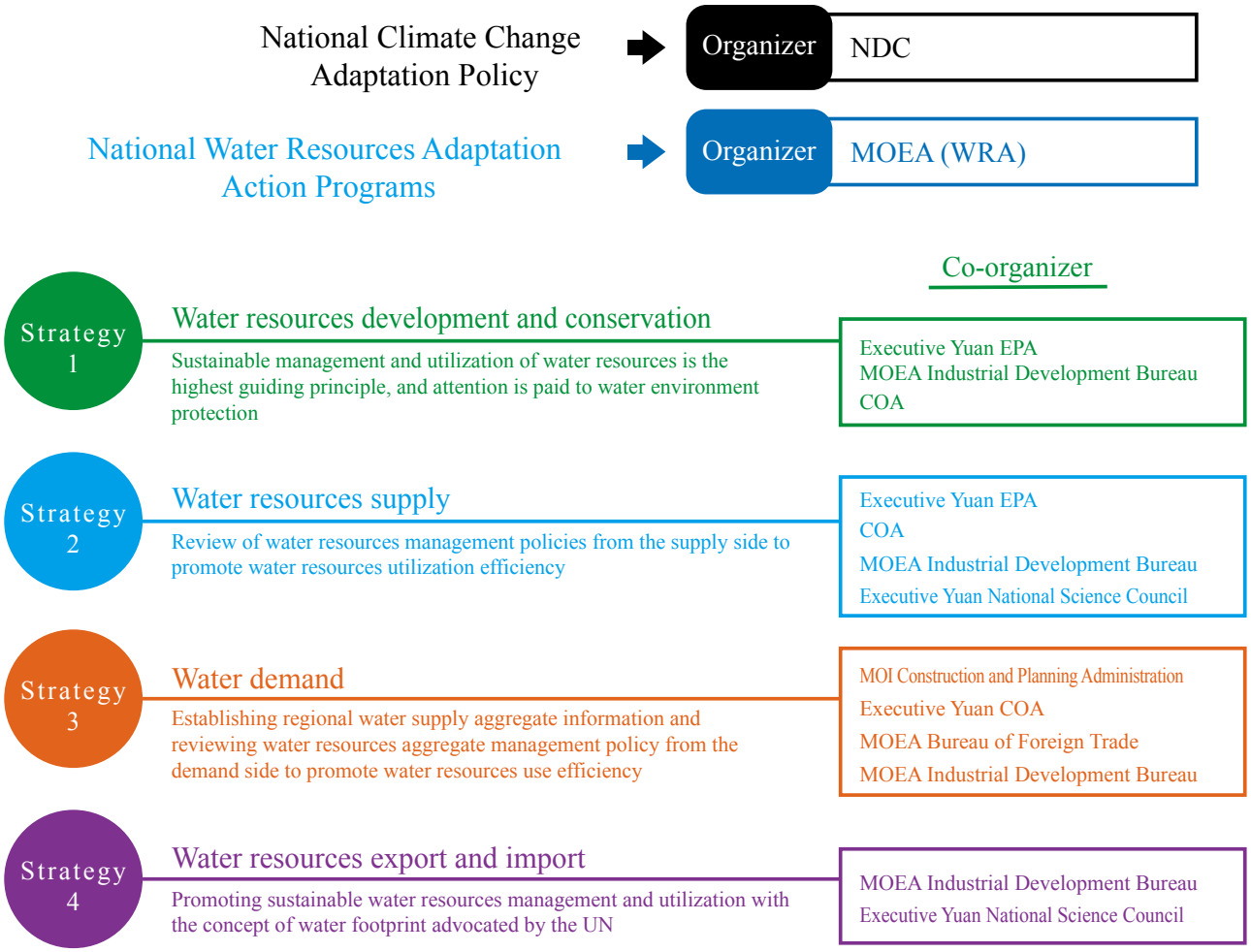


Figure 6.3.6 Framework of promoting National Water Resources Adaptation Action Programs

Source: National Development Council (NDC), National Climate Change Adaptation Action Program 2013-2017 Implementation Achievements Report, 2018.

4) Land use

Taiwan enacted the Spatial Planning Act in 2016 to clearly incorporate climate change into national spatial plans, setting out disaster prevention strategies and climate change adaptation strategies as the guiding principle for local governments to draft national spatial plans in municipalities, counties and cities. In 2015, the Coastal Zone Management Act was enacted to prevent coastal disasters and environmental damage caused by climate change. In 2015, the nine sub-laws in the Wetland Conservation Act and its Enforcement Rules were brought into effect to regulate water resources and change microclimate through wetland conservation, and to exert self-adaptation mechanisms under climate change. In 2017, the national regional plan was revised to incorporate spatial planning into the climate change adaptation strategy, and the supporting mechanism of land use management was formulated for the climate change adaptation strategy. The land use plans at all levels should collect relevant information such as disaster potentials and disaster prevention maps, and incorporate them into the planning reference of environmentally sensitive areas, so as to review land use zoning and land use areas. Moreover, land use and land cover change in Taiwan are monitored continuously and regularly. Land use change monitoring operations based on remote sensing satellite images provide comprehensive and sustained land change information and grasp land cover change and disaster-sensitive areas in order to cushion climate impact.

5) Coastal Areas

To achieve the goal of sustainable coastal development, Taiwan is actively engaged in the prevention and control of coastal disasters and environmental damage, conservation and rehabilitation of coastal resources, with the aim of providing buffer against the impact of coastal disasters, preventing land erosion, improving the seawall landscape, and restoring the coastal environment. In 2017, the "Integrated Coastal Management Plan" was formulated, which stipulates the guiding principles for the overall utilization of coastal areas, guides and integrates the management of coastal zones, actively protects natural resources and prevents disasters, so as to strengthen the security of the areas along the coast. Degraded habitats are being rehabilitated and subsidence areas transformed into wetland ecological parks to promote wetland environmental education among communities. Wetland environment, educational publicity and community participation are built to improve coastal ecological habitats and wetland environment, which will mitigate climate impact. In promoting the geomorphological modification and transformation program in land subsidence areas, the "Specific Solutions and Action Program for Ground Subsidence in the Yunlin-Changhua Region" has imposed regulations on land use and control in the serious land subsidence areas, which addresses the rational and effective use of land in the serious subsidence areas and improves the drainage in those subsidence areas in Changhua and Yunlin counties. The public wells of Changhua and Yunlin irrigation associations were also closed to reduce the amount of groundwater pumping and slow down the subsidence of the ground. Additionally, the database of monitoring, investigation and assessment has been established to improve the marine meteorological forecast and implement the application of climate information. Currently, the observation data and climate variability characteristics analysis report

of Taiwan observation stations from 1911 to 2013 have been completed, while the 37-year storm tide database and warning tide level of the coasts have been analyzed, developing the ability of Taiwan for climate change projection. Further, the capability of pollution monitoring and risk control in coastal areas is being strengthened. Regular sampling, monitoring and data quality assurance of environmental water quality such as rivers, reservoirs, sea areas and groundwater are being carried out to provide people with timely and up-to-date environmental quality information.

6) Energy supply and industry

Systematic management mechanisms have been established to develop energy industry adaptation tools and guide energy industry adaptation, constructing a climate change adaptation platform in the energy field, collecting information, and promoting energy industry adaptation for the purpose of building a top-down system management mechanism. In order to reduce the vulnerability of Taiwan's manufacturing industry to the impact of future climate change, the industrial adaptation action is based on building a bottom-up facility inventory and guidance framework of fully adjusting the environment, enhancing adaptability, and stepping up the promotion. The overall driving framework of the action program in the field of energy supply is shown in Figure 6.3.7.

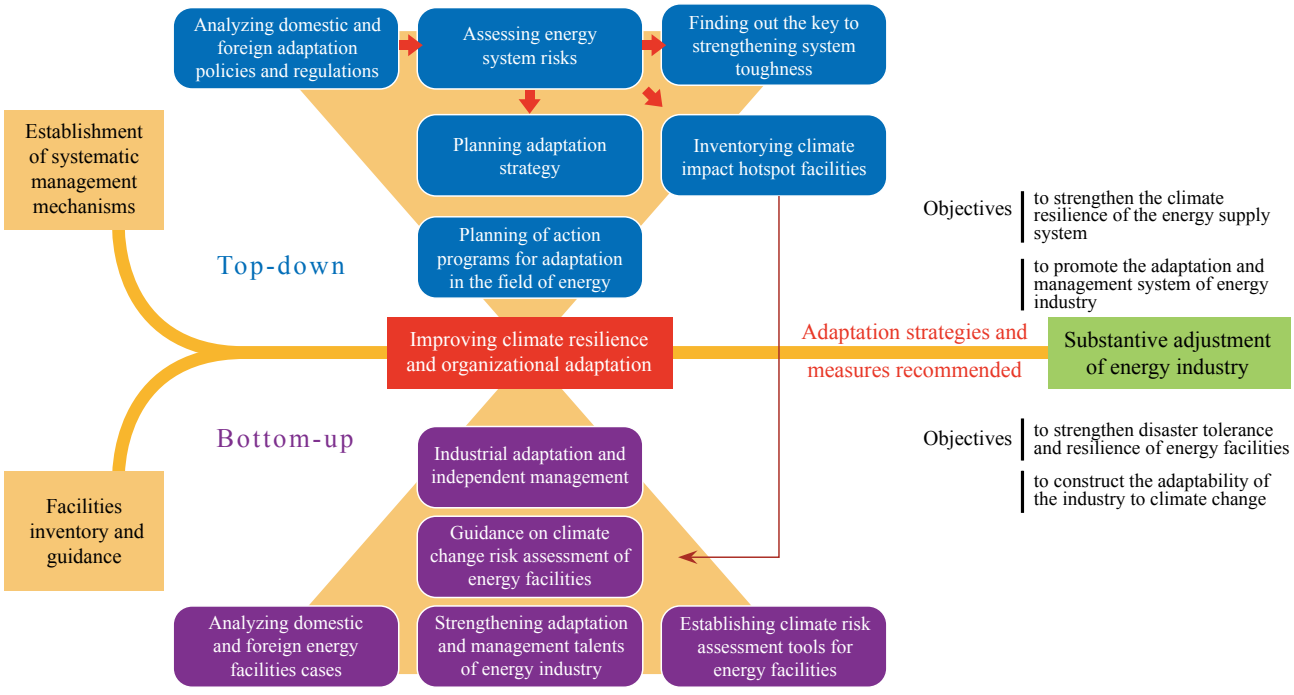


Figure 6.3.7 Framework for promoting climate change adaptation in the energy field

Source: National Development Council (NDC), National Climate Change Adaptation Action Program 2013-2017 Implementation Achievements Report, 2018.

7) Agricultural production and biodiversity

To adjust the production, maintenance and management modes of crops, livestock and fisheries in a timely and appropriate manner, the Executive Yuan Council of Agriculture (COA) has maintained appropriate amounts of and high-quality agricultural land through the use of agricultural land and water resources planning, and strengthened the facilities for regulating and storing agricultural water, so as to boost the efficiency of water resources utilization and increase economic benefits. In response to climate change, the agency has adjusted farming systems, guided the farmland under contract to import alternative crops with the potential for exports, developed diversified utilization of farmland, balanced domestic grain supply and demand, and promoted the food self-sufficiency ratio. The COA also guided the transformation of the agro-food industry to refined cultivation, promoted the upgrading and renewal of production facilities, handled agricultural disaster reduction and engineering management, and carried out the transformation of hillside agriculture, taking into account the improvement of water resources conservation and ecological environment, alleviating the risk of abnormal climate to agricultural management, and thereby stabilizing the supply and marketing of agricultural products, maintain food security and competitive advantage of the agro-food industry.

The agency established agricultural monitoring and evaluation systems and industrial risk management, carrying out crop simulation and prediction, creating an early warning system, and planning suitable planting areas and industrial evaluation, which serves as the basis for subsequent adjustment and adaptation of the farming system. Moreover, to alleviate the heavy losses suffered by farmers and fishermen as a result of natural disasters and establish an income security network for farmers and fishermen, the COA has offered crop insurance on a trial basis since 2015, and according to the items that are vulnerable to natural disasters or epidemics as fed back in the inventory by establishments, priority was given to the development of insurance policies in order to stabilize the income of farmers and fishermen. In the meantime, the COA developed the Guide of Subsidizing Natural Disaster Insurance in Agriculture Industry on a Trial Basis, which will be in parallel with the agricultural natural disaster relief system during the pilot period. In an effort to strengthen the ability of R&D to resist reversal condition, the Council of Agriculture (COA) has established a germplasm exchange plan and the application of R&D of stress-resistant varieties, shortened the breeding R&D time through breeding technology, and planned to build a stress simulation test field, so as to expand the selection of stress-tolerant varieties, and those able to adapt to climate change in Taiwan for a long time, so that technical R&D could be adjusted to enhance the industry's ability to resist stress.

Taiwan actively promoted the Satoyama Initiative, proposed the Taiwan Partnership for the Satoyama Initiative (TPSI), formulated the Green Conservation Label, and launched the eco-friendly forestry production system. In 2017, the nation drew up the “Operating Guideline for Certification of Traceability by Certification Bodies” and "Identification Label of Domestic Wood and Bamboo Materials" to establish the legitimacy of the source of domestic wood and bamboo materials and quality management of processed products, enhance the sustainability and market competitiveness of domestic bamboo and wood, establish a multi-objective and sustainable high-quality forestry management adaptation model and promote green afforestation. In

order to slow down the loss of biodiversity caused by human disturbance, the COA formulated and amended the “Quarantine Requirements for the Importation of Plants or Plant Products into Taiwan” and the “Guidelines Governing the Review of Applications for Permission to Export or Import Live Wildlife and Products,” creating a common operating platform for customs clearance, keeping abreast of international animal and plant epidemic situations, amending domestic epidemic prevention laws and regulations, and conducting surveillance work to assess, detect, monitor, prevent and control alien invasive species. To restore ecosystems in degraded areas, the COA Soil and Water Conservation Bureau carried out the restoration plan for degraded ecosystems, while the Forestry Bureau undertook the rehabilitation plan for degraded habitats to mitigate the impact of human disturbance on biodiversity. To strengthen biodiversity monitoring, data collection, analysis and application, and to assess the vulnerability and risk of biodiversity, the COA initiated the "Biodiversity Information Center Establishment Project" by linking up with species distribution data from the Forestry Bureau, the Endemic Species Research Institute, and the Forestry Research Institute, and by integrating them into the Taiwan Biodiversity Information Facility (TaiBIF) to provide various biodiversity thematic information services for application and use, and offers management, governance reference and integration with international databases. By integrating the biodiversity research results from various domestic institutions, it has developed regional and national biodiversity indicators constructed the "national biodiversity indicator monitoring and reporting system," and grasped the current situation and changes of the ecosystem by coordinating with the existing monitoring system. By integrating the information about threatened species in Taiwan, it established a "Redbook information network framework" on different biological species, attributes and threatened situations. In addition, the long-term accumulated chronologic data of the Taiwan Biodiversity Network was structured to achieve the purpose of data collection, circulation and utilization. The agency also further promoted the assessment and prediction of the impacts of climate change on ecosystems, subsidized the Research on Biodiversity Vulnerability Assessment and Risk Management in Response to Climate Change, and the Research on Biodiversity Resilience in Response to Climate Change, in order to understand the impacts of climate change on more sensitive and endangered species in Taiwan, the populations and ecosystems, in addition to adopting appropriate measures.

8) Health

Warming will increase the risk of the prevalence of communicable diseases and the mortality rate of cardiovascular and respiratory diseases. To ease the burden for public health and medical systems, the Ministry of Health and Welfare (MOHW) in 2014 revised the Regulations for the Occupational Safety and Health Facilities, requiring laborers to take precautions against heat illness caused by high temperatures in the workplace. The agency in 2015 amended some provisions of the Communicable Disease Control Act to impel the public to actively cooperate with the government's epidemic prevention measures. Units at all levels have taken turns to conduct disaster prevention and rescue exercises in counties and cities, before the flood seasons, as did the subsidized medical institutions, since 2010. The Ministry of Labor has incorporated emergency response into the educational training of safety and health personnel, and required business entities to incorporate emergency response measures into occupational safety and health management plans and

to conduct regular exercises. By launching publicity campaigns for climate change and post-disaster epidemic prevention, public awareness of health has been raised. The agency also continued to conduct health impact and adaptation studies to shed some light on the correlation between climate change events and chronic diseases, and develop related assessments; expand the pooling of disease assessment-related databases and complete the pooling and analysis using data on specific diseases, meteorology, and population; promote the operating procedures for environmental information exchange, accelerate environmental information exchange operations; build animal epidemic databases; provide the impact of climate change on vector-borne mosquitoes and zoonotic diseases and countermeasures; establish an occupational injury and illness notification system and count the number of reported cases of occupational injuries and illnesses caused by heat illness. Moreover, it has been strengthening the environmental establishment and maintenance of monitoring systems, manages, maintains and updates information from the statutory communicable disease notification system, epidemic investigation system and infectious disease warehousing system every year, and boosts the effectiveness of notification of dengue fever, Japanese encephalitis and other communicable diseases related to climate change, so as to gradually improve the integrated environmental and health information system through the above efforts.

Reference

1. Ministry of the Interior (MOI), Land Use Action Program (2013-2017), 2014.
2. Ministry of the Interior (MOI), Coastal Action Program (2013-2017), 2014.
3. Ministry of Transportation and Communications (MOTC), Action Program for Subsistence Infrastructure (2013-2017), 2014.
4. National Development Council (NDC), National Climate Change Adaptation Policy Guideline, 2012.
5. Executive Yuan Council of Agriculture (COA), Action Program on Agricultural Production and Biodiversity (2013-2017), 2014.
6. Ministry of Science and Technology (MOST), Disaster Action Program (2013-2017), 2014.
7. National Science and Technology Center for Disaster Reduction (NCDR), The Past and Future of Taiwan's Climate, Excerpts from the Taiwan Climate Change Science Report 2017—Physical Phenomena and Mechanisms, 2018.
8. National Science and Technology Center for Disaster Reduction (NCDR), Taiwan Climate Change Science Report 2017—Physical Phenomena and Mechanisms, 2017.
9. National Development Council (NDC), Operational Guidelines for the Planning of Local Climate Change Adaptation Program (updated version), April 2018.
10. National Development Council (NDC), National Climate Change Adaptation Action Program (2013-2017), 2014.
11. National Development Council (NDC), National Climate Change Adaptation Action Program (2013-2017) Implementation Achievements Report, April 2018.
12. Ministry of Economic Affairs (MOEA), Water Resources Action Program (2013-2017), 2014.
13. Ministry of Economic Affairs (MOEA), Energy Supply and Industry Action Program (2013-2017), 2014.
14. Ministry of Health and Welfare (MOHW), Health Action Program (2013-2017), 2014.
15. Executive Yuan Environmental Protection Administration (EPA), Integrated Information Network on Climate Change.

▲Dongshan River

Chapter 7
Technical R&D, Demand and Transfer

Chapter 7
Technical R&D, Demand and Transfer

To develop the available technology and techniques for climate change resolution, the international community has incentivized R&D, innovation and cooperation. In cooperation with global market mechanisms and climate finance, countries list the technological and technical components in demand, while designing and promoting domestic action plans to import or export relevant technology for transfer and diffusion. Taiwan also invests in R&D in climate technology, climate services and relevant industries, which are divided into two categories: "mitigation and energy technology" and "climate service and adaptation technology". The following section introduces the cases of technology demand and technology transfer.

7.1 Technical R&D

7.1.1 Mitigation and Energy Technology

The principal element of energy conservation is the development of key components for system integration, especially under the request of the industry. The program is further divided into four sectors: residential and commercial energy conservation, industrial energy conservation, transportation energy conservation and campus energy conservation. These sections establish the framing of policy implementation and the techniques on energy conservation.

In the residential and commercial sector, the "TaiSEIA 101" (which is a standardized method on household IoT technology) has been registered as a national standard. Additionally, a pilot project of a Virtual Power Plant had been established, which included the participation of low voltage business users. In the project, each user had to lower their energy usage by 0.69kW on average, matching the result of PG&E Smart AC Program in California, United States of America. In the field of Energy Information and Communication Technology, Advanced Metering Infrastructure and energy management are two of the included areas. Furthermore, significant progress was achieved in R&D, the promotion on LED and OLED lighting system and high benefit-cost ratio solid-state lighting technology.

NEP has focused on the basics of energy technology. Moreover, it also emphasized the implementation in the energy industry, while focusing on the industrialization of energy technology and the transfer of results from scientific research into the industry. During the 2nd phase of the NEP, the program has advocated for the investment of over 6.9 million from related companies on R&D in energy technology and 3.7 million from the production investment, which allows the upgrade and transfer of domestic industries. Nevertheless, in light on the Nationally Determined Contributions (NDCs) to carbon emission reduction and the demands from the industrial sector, the MOEA has been continuously involved in the development of technology and methods on energy conservation, focusing on energy management, experimenting the effect of techniques and establishing application cases. The following sections introduce the six main programs of NEP II which illustrate the emphasis on mitigation and energy technology.

1. Energy Conservation

The principal element of energy conservation is the development of key components for system integration, especially under the request of the industry. The program is further divided into four sectors: residential and commercial energy conservation, industrial energy conservation, transportation energy conservation and campus energy conservation. These sections establish the framing of policy implementation and the techniques on energy conservation.

In the residential and commercial sector, the "TaiSEIA 101" (which is a standardized method on household IoT technology) has been registered as a national standard. Additionally, a pilot project of a Virtual Power Plant had been established, which included the participation of low voltage business users. In the project, each user had to lower their energy usage by 0.69kW on average, matching the result of PG&E Smart AC Program in California, United States of America. In the field of Energy Information and Communication Technology, Advanced Metering Infrastructure and energy management are two of the included areas. Furthermore, significant progress was achieved in R&D, the promotion on LED and OLED lighting system and high benefit-cost ratio solid-state lighting technology.

In building energy conservation, the program focused on the distribution of Optimal Energy-Saving Control of Water Loop in HVAC Systems, the expansion of the Building Energy Models cloud computing, the development of energy-saving control on packaged air-conditioner and central air-conditioning systems and the development of Online Building Energy Models techniques. In the industrial energy conservation, the most relevant issues include Work in Process and environmental simulation monitoring, which are part of a pilot project in the progress on regional energy integration. In transportation energy conservation, efforts are made on the vehicles and power trains by the R&D of lightning and smartening of transports. Finally, the campus energy conservation sector focuses on the construction of high-efficiency energy-saving data center and optimization of the information appliance management.

2. Alternative Energy

The principal elements of alternative energy referring to foreign and domestic blueprints on mitigation are the three sectors proposed in the project: bioenergy, photovoltaic energy and energy saving. The consumption of fossil fuel can be reduced by promoting the use of clean alternative energies and increasing and strengthening alternative energy-related industries

The bioenergy project includes cellulosic ethanol, long-chain biofuel and the application of high-value biomass. The photovoltaic energy project focuses on electricity generation and heating from solar power, using sophisticated techniques with high quality-price ratio solar cells, module packaging technology and industrial application processes. Last but not least, the energy storage project is composed of lithium-ion battery systems, flow battery systems, hydrogen and fuel cell systems, which includes the production of a pilot run on Self-Terminated Oligomers with hyper-Branched Architecture material, the pilot project of integration on reusing repurposing batteries system, technology transfer on solid oxide fuel cell generator, aluminum battery application on stationary power systems and markets of battery jars for automobiles and light vehicles.

3. Smart Grid

The principal focus of the smart grid program aims to dedicate in smart meter development, promotion of renewable energy and energy demand regulation, the development of the Taipower Company transmission-distribution infrastructure construction, and the establishment of Penghu Low Carbon Island by Executive Yuan. Some of the key outcomes achieved during the first phase of the project were technology transfer and mechanization. In Penghu, the first Smart Grid Demo Site was successfully deployed. To promote the smart grid industry in full scale, the Virtual Power Plant Demo Site of the smart grid program can be applied in the Taipower system and to household users through integrating the demand response system, distributed energy sources and energy storage.

In terms of Photovoltaics (PV), smart inverter and gateway system are developed on the basis of embedded systems, which can optimize the energy generation power and real power adjustment through 4G wireless internet. Through such means, the impact of renewable energy towards the grid can be lowered by more than 30%. Moreover, the first integration of public housing and a smart energy management system has been realized in the Shingrong Public Housing. In cooperation with the Government of Taipei City and the Taipower Company, household energy-saving, visualized interface of electricity usage analysis, renewable energy system, energy storage system electric vehicle charging system and automatic energy demand response system are applied in the public housing accordingly.

4. Offshore Wind Power and Marine Energy

Off-Shore Wind and Marine Energy were developed in the NEP Phase one on the basis of off-shore wind energy and the Kuroshio Current electricity generation, which have been completed with the collection of relevant data for R&D. Located in Siao Liouciou, open sea and mounting tests concluded with an average generation of 32.57 kW under steady flow velocity of 1.43 m/sec. The test was done through loading a 50kW generator on a deep-sea mooring system for four days.

Additionally, an experimental test of the 5mW offshore wind turbine blade rotation angle control system was conducted under a controlled simulation that combined the generator and the power conversion mode. The whole system dynamics of Sinosteel 5mW offshore wind turbine combines wave force, aerodynamics, fan system dynamics, dynamic analysis of control system, innovative integration of aerodynamics, fan system dynamics, dynamic analysis of control systems, wave force and other analytical tools. Therefore, the simulation can be applied to analyze the motion state of offshore wind turbines under different wind conditions.

Furthermore, Taiwan has improved the development of environmental maritime constructions and short-term forecasting technology. Taiwan also successfully integrated maintenance and operational decision-making technology, including sea meteorological data, marine forecast data, hurricane farm data and operational data monitoring among others, providing a single interface for the operation of the cross-wind farm. By Improving the operation and maintenance energy, the island enhances the overall availability and power generation output of the offshore wind farm.

5. Geothermal and Gas Hydrate

When the Central Geological Survey of the Ministry of Economic Affairs started an investigation

in 2004, found out that there is a relatively high amount of methane resources in southwestern Taiwan, which can be used as natural gas resources. Taiwan's current geothermal technology development includes non-volcanic geothermal systems and volcanic geothermal systems. The former has actively developed in recent years organic Rankine dual-cycle power generation systems, geothermal reservoir management and monitoring technology and scale suppression technology, among others. In 2012, the Qingshui geothermal 50kW double-circulation geothermal power generation demonstration system was built in the geothermal area of Yilan. The current state of research and development in recent years has been focusing on strong acid corrosion and acid resistance fo surface facilities since 2013. The etching coating technology and the acid-resistant pipe manufacturing technology in the downhole have been successfully applied to the heat exchanger of the generator set in the acid-resistant coating technology, and the low-cost acid-resistant pipe manufacturing part is still in the process of research and development.

Additionally, in recent years, underwater detection equipment and maritime testing have also been developed, such as deep sea real-time image guiding instrument stage, laser optical detection system and video guiding grab system among others. The equipment aims to add more accuracy and efficiency to geothermal detection. Taiwan's Industrial Technology Research Institute (ITRI) has designed its own geothermal power generation system technology, which is produced domestically, and includes dual-cycle ORC generator sets, increasing heat extraction systems, tailwater reinjection systems and automatic control systems.

6. Carbon Reduction and Clean Coal

Taiwan is also committed to research and development of carbon reduction technologies such as carbon capture, storage and utilization (CCSU) and new combustion systems to reduce pollution. Under the carbon-reducing clean coal main shaft, the calcium-capacitor is currently the most significant development for capture CO_2 technology. It is one of the most effective treatments for the improvement of major carbon emissions sources such as coal-fired power plants and industrial furnaces. The pilot plant established can significantly reduce the system footprint and energy consumption and has a more competitive advantage.

Additionally, Taiwan has also promoted 13 energy technology industries such as Taipower Company, CPC Corporation and private power plants to implement energy reduction technology applications and substantial reductions in energy efficiency, including the use of low-carbon fuels, unit efficiency and waste gas recovery. Finally, in order to promote the public's understanding on the current state and future development trends of energy technology, national energy supply and demand policies, and the cost of different energy options, the "Taiwan 2050 Energy Supply and Demand Simulation System" has been developed to help understand the energy transition pathway of carbon reduction and coal clean-out by operating the scenario simulator.

7.1.2 Climate Service and Adaptation Technology

To face the influence and impacts of climate change, human society should address these challenges with mitigation and adaptation actions. The

planning and implementation of climate adaptation actions rely on the collection of meteorological and climate data, as well as the assessment of regional vulnerability and exposure. After accumulating data and information, the knowledge should be outputted and converted to climate adaptation actions. The technology and techniques used in the process include "climate services" and "adaptation technology."

The recent research of climate service in Taiwan is mostly implemented by the Central Weather Bureau (CWB), such as the "Climate Change Application Service Capacity Development Project", which "provides science-based climate forecast information for government and society's climate risk perception and management". The focus of climate service development includes the construction of R&D models, capacity building of climate science, the integration and processing of climate data, climate monitoring and forecasting, climate application services, and promotion and support for climate change adaptation.

Additionally, the National Science and Technology Center for Disaster Reduction (NCDR) provides information on the application of climate change adaptation for government agencies by providing information on Taiwan's climate change analysis and projection. While reducing the impact of climate change, CWB and NCDR support domestic private industries and government units to establish a climate risk assessment mechanism to play a role in climate change adaptation.

Also, Taiwan engages in a case of climate change adaptation action conducted by a public-private partnership, the Delta Electronics Foundation, the Central Weather Bureau, the Taiwan Architecture & Building Center and the International Climate Development Institute. They jointly developed the "Building Micro-climate Database", which applies the historical meteorological data of the 13 stations in the metropolitan areas into the building information model (BIM), allowing the architect to consider 24 important meteorological information such as sunshine, wind speed, temperature, humidity and rainfall at the beginning of the design; leading to further green building design with better ventilation, natural lighting and green belts that help to reduce the energy consumption of buildings from the beginning.

The intelligent residential space display center building in Wanlong Taipei and the Changhua Tianzhong Meteorological Station under construction have all used this building microclimate database for energy saving inspection. The Taiwan Architecture & Building Center will also apply it to the future Taoyuan Aviation City. In terms of planning, Taiwan-designed buildings can be more energy efficient. Plans to design an online information platform that provides higher resolution and considers regional microclimate effects have been established to provide architects with more accurate microclimate information that create energy-efficient buildings. This information is also expected to serve as a basis for building owners and managers to control the building's air-conditioning and lighting systems, as well as supporting information for applications such as solar energy, wind energy and smart grid power dispatching.

Additionally, the International Cooperation and Development Fund (hereinafter the ICDF) is a full-time international aid agency in Taiwan. It also uses Taiwan's climate services and adaptation technology actively to help our friendly nations and countries with strengthening the ability to establish and use climate

data, supporting the promotion of their Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs).

7.2 Technical Demand and Transfer

As the greenhouse effect intensifies, the global impacts of climate change are becoming more serious. The United Nations Framework Convention on Climate Change (UNFCCC) uses four major approaches to combat climate change. First, "mitigation" focuses on reducing greenhouse gas (GHG) emissions in the atmosphere; the second is "Adaptation", which looks to adjust and adapt the need responses to environmental changes; the third is "Technology" which drives mitigation and adaptation actions; and the last one is "Finance" required for supporting the development of these actions. This section introduces Taiwan's technology needs in response to climate change and technology transfer cases involving international technical cooperation.

7.2.1 Technical Demand

Taiwan's offshore wind power technology industry promotion strategy is to establish a model for the application of domestic offshore wind farm investment, which builds offshore wind farms in the form of an Industrial Development Zone while promoting international cooperation to establish Taiwan's offshore wind through the input of optimal technology. Independent research on energy industry supply chain and development design energy is aim to build offshore wind power maritime engineering independent construction capabilities together with domestic maritime engineering vessels. Further goals include coordinating the needs of domestic offshore farm developers, domestic wind power equipment

Table 7.2.1 Offshore Wind Power Development Assessment of Natural Conditions of Taiwan's Marine Energy

Marine Energy	Ceiling Capacity / Reserves	Devirative Economic Benefits	Clean and Sustainable	Energy Security/ Stability	Cost Competitiveness/ Technology Maturity
Ocean Current	◎	△	◎	◎	△
Tide	△	△	◎	△	○
Wave	△	○	◎	△	○
Temperature Difference	△	○	◎	○	○
◎ High ○ Medium △ Low					

Source: Ministry of Science and Technology, Report of Promotion and Management Project of Offshore Wind Power and Marine Energy Focus Center (IV) Phase II of the National Energy Program (NEP-II), 2017

manufacturers and maritime engineering enterprises to help build long-term Partnerships. In response to the research and development of wind-measuring technology, we have established a system-wide maintenance technology capability, and through the cooperation of the industry to domestic manufacturers, we are actively developing offshore wind farms and enhancing the key technologies of operation and maintenance.

7.2.2 Technical Transfer

The Technology Mechanism established by the UNFCCC consists of the Conference of the Parties (COP), the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN). Among them, the development, diffusion and transfer of technology are currently widely used execution tools, as listed in Table 7.2.2. The so-called technology development stage analyzes the life cycle of multiple technologies, classifies and analyzes the technical effects, sorts them, and then, enters the stage of technology diffusion. Diffusion is conceived by making society accept this technology. In terms of application, which the core is the industrial development of technology, it must be considered the economic and commercial driving forces of the market, industry and life-sustaining facilities. After the development and diffusion of technology, mature, relevant experience can be exported to the international, through technology transfer, in addition to meeting regional challenges, also achieves the goal of global climate action.

To promote Taiwan's participation in international climate cooperation over the globe, and in line with the spirit of the UNFCCC and the Paris Agreement, the Ministry of Foreign Affairs (MOFA) is actively promoting the application of climate mitigation and adaptation of science and technology to international climate action. In the context of Taiwan's full-time foreign aid agencies, the International Cooperation Development Foundation (ICDF) and relevant ministries assist our friendly nations and countries to strengthen their ability to cope with climate changes. This section introduces Taiwan's important technology transfer cases in international climate cooperation.

Table 7.2.2 Objective and Implementation of Technology Development, Diffusion, and Transfer

Technology Policy Instrument	Objective	Implementation
Technology Development	1. Technology R&D 2. Technology assessment 3. Enhancing capacity building	Analysis on technology life cycle and phase Introductory stage, growth stage, maturity stage, decline stage Technology classification New technology, germination technology, key technology, fundamental technology Analysis on technology function and efficiency and continuous investment of R&D
Technology Diffusion	1. Technology accepted and applied by the society 2. Technology industry development	Technology and commercialization Technology maturity, commoditization timeline, research and development knowledge, predictability, commoditization Comprehensive industry analysis Presenting the technology maturity, market value (amount) and application potential of each project adaptation technology
Technology Transfer	1. Application of international cooperation 2. Technical demand assesssment 3. Technology training 4. Capacity building	Intellectual property rights transfer The authorization and use of knowhow Establishing domestic and international technology transfer mechanisms and paths

Source: Ministry of Science and Technology, Report of Promotion and Management Project of Offshore Wind Power and Marine Energy Focus Center (IV) Phase II of the National Energy Program (NEP-II), 2017

1. Solomon Islands Synergistic Analysis for the Environment, SoSAFE

The Central Weather Bureau (CWB) of the Ministry of Transportation and Communication has developed a meteorological and seismic early warning system and technology for the long-term, has promoted the application of climate change, and has signed a memorandum of understanding on meteorological cooperation with the Solomon Islands Ministry of Environment in 2017.

In 2016, CWB, Ministry of Health and Welfare, Academia Sinica, Chung Yuan Christian University and the Meteorological Society of the Republic of China jointly proposed a three-year “Solomon Islands Meteorological and Earthquake Early Warning Research” project, supported by the Ministry of Science and Technology. That is to say, the team will be dispatched to the country to carry out the work of setting up the meteorological and seismic observation systems and strengthening the operation plan. The first phase focused on the development of the infrastructure of the Solomon Islands with a Synergistic Analysis for the Environment (SoSAFE). Both countries are facing similar threats of natural disasters such as severe weather conditions and earthquakes. Through the cooperation between the two countries, the Solomon Islands have built a number of meteorological and seismic observation facilities, which have early warning capabilities for the occurrence of heavy rains and earthquakes. Early warning mechanisms for the outbreak of dengue fever have also begun to be established.

2. Central America Geographic Information System Application Capacity Enhancement Program

This project is an aid program in Nicaragua and Honduras conducted by the International Cooperation and Development Fund (ICDF) under the commission of the Ministry of Foreign Affairs. The partners include government agencies in the implementing countries. In the case of Nicaragua, the partners include the Nicaragua Land Monitoring Agency (INETER), the Nicaragua Ministry of Environmental Resources (MARENA), and Nicaragua Mana. In Honduras, the principal partners are Autonomous University of Water Resources Research Center (UNAN-CIRA), Honduras Department of Natural Resources and Environment (SERNA), Honduras Forest Service (ICF), Honduras National Disaster Relief Committee (COPECO), and Honduras National Water Company (SANAA).

The threat of natural disasters frequently encountered by Central American countries is the core problem for resolution. Due to the lack of effective management and planning of the vast territory of the cooperating countries, which affects the regional sustainable development, it is urgent to use effective scientific and technological tools to assist the government in decision-making processes on natural disaster prevention, land change management and sustainable use of natural resources. Because of Taiwan's advanced satellite technology capabilities, the Central American friendly nations Nicaragua, Honduras and El Salvador have asked Taiwan to introduce GIS technology to improve governance capabilities through this project and strengthening the cooperation between countries. The project is implemented in a regionally integrated manner, and the principal axis of the project is drawn upon a common base as there are shared needs and resources that can be saved by sharing resources.

After the assessment, the main challenge of introducing GIS applications in Nicaragua and Honduras is the lack of satellite images and technical capabilities, the inability to effectively grasp land use and land changes, and the lack of ability to respond quickly and effectively in the event of natural disasters and losses. To assist the partner countries to effectively apply the geographic information system and to improve the efficiency of government governance, the principal contents of this project are described below:

(1) To strengthen environmental monitoring in nature reserves or key areas, and provide satellite imagery from Taiwan to assist cooperative countries to grasp the situation of land changes;

(2) To cultivate GIS technology talents and transfer satellite images application technology to cooperative countries;

(3) To produce satellite images assisted water quality monitoring (Nicaragua), environmental management (Honduras) based on the individual needs of the partner countries.

3. Honduras Forest Pest Management Project

This project is an aid program commissioned by the Ministry of Foreign Affairs in Honduras, the partner being the Honduran National Forest Protection Agency (ICF). The main goal of the project is to assist Honduras in developing climate change strategies for climate change and to use forest health, disaster management and geographic information system (GIS) technology to construct the Honduras Forest Health Management Decision Support Platform while enhancing macros. The country's forest health and management efficiency are expected to shorten the

pest strain time to one week, which will increase the forest carbon sequestration and reduce the loss of forest pests. Additionally, with the assistance of the Honduras National Greenhouse Gas Report in the forestry sector computing technology and the forest management decision support platform transfer, the goal of strengthening the capacity building of the Honduras environment and forestry sector has been achieved. The forest management technology and application adopted by our plan are:

(1) Digitalization of forest management information;

(2) Transfer the small locust survey and outbreak prediction mechanism to construct an early warning mechanism for forest pests;

(3) Integrate forest pest control resources with GIS technology;

(4) Introducing forest pest damage estimation mechanism.

Figure 7.2.1 Collaborated team from ICDF and Ministry of Environment of El Salvador examined the change point of land use

Source: The International Cooperation and Development Fund (TaiwanICDF)

Figure 7.2.2 The pest management workfore of Honduras introduced the usage of the bark-beetle trapper

Source: The International Cooperation and Development Fund (TaiwanICDF)

4. St. Kitts and Nevis Agriculture's Adaptation to Climate Variability Adjustment Program

This case was commissioned by the Ministry of Foreign Affairs in St. Kitts and Nevis. The partner is St. Kitts and Nevis Ministry of Agriculture. St. Kitts and Nevis suffered a severe drought in 2015. After the decrease of the total crop output by 31.2% compared with 2014, which affected national food security and farmers' livelihoods; the country requested Taiwan for help. Literature research and field visits confirmed the importance of some issues, such as the impact of climate variability and climate change for the agricultural development of the country. After the initial assessment of the agricultural vulnerability of the country, the core problem was defined as "the lack of information for a national agriculture program for early warning and adjustment of climate variability".

The project aimed to improve the resilience of the agricultural system of the country by "establishing early warning information collection mechanisms", "developing and introducing crop disaster prevention technologies", and "improving agricultural information dissemination rate". At the end of the project, the country's agricultural administration department will acquire disaster prevention and reduction information dissemination mechanisms that will allow applying this information to reduce damage. The plan will enhance Taiwan's efforts and contributions to global climate change, also by implementing Article 11 of the Paris Agreement on "Capacity Building". "States Parties should assist climate-responsive countries in developing a climate-responsive capacity building, including mitigation and adaptation actions, practical actions in technology transfer and development, climate finance, and rising climate awareness through education and training, helping to enhance our international participation".

5. Pilot Project of Myanmar Rural Micro-concentrated Power Supply Station

According to the World Bank, in 2014, only 30% of the country's population had access to a power supply, while most rural areas experienced even higher levels of distress. By 2016, two-thirds of households were still unable to connect to the grid, affecting people's daily lives, education, health and safety, while further hindering the development of local economic activities. Therefore, rural power supply and lighting have been listed by the Myanmar government as an important poverty alleviation strategy and a national development goal.

The International Cooperation and Development Fund piloted at the designated location of the Myanmar Government by means of a Pilot Project. The Animal Husbandry and Irrigation and the Rural Development Division of the Ministry of Agriculture appointed the Industrial Technology Research Institute of the Ministry of Agriculture as a technical consultant. The public bidding method sought Taibang Technology Co., Ltd. as the system construction manufacturer. The project combines the stable and plentiful solar potential characteristics of Myanmar with the advantages of Taiwan's complete solar photovoltaic technology and industrial chain to provide an off-grid centralized power supply system for remote villages that cannot be reached in a short period. Its principal goal is to provide the basic power required for night lighting of households and public facilities.

By participating in the construction work, the villagers will enhance the recognition and responsibility for the project, facilitating the system to operate without obstruction. The plan includes:

(1) Planning and construction of micro-concentrated solar power supply systems and power-saving lamps;

(2)Counseling and benefiting villagers to set up the power station management committee to be responsible for system maintenance and provide education and training, including the organization and operation of the management committee, the operation and maintenance of the power station, and the promotion and execution of the charging mechanism;

(3) Verifying system performance and power station operation status, correct and establish appropriate power supply operation modes in line with to actual conditions.

In 2017, the Taiwan team established three sets of micro-concentrated solar photovoltaic systems and power-saving lamps in the Magway Region and Sagaing Region, in central and western Myanmar. After half a year of trial operation, the project provided electricity to a total of 5 villages. Around 560 households and primary facilities such as temples, schools, and streets enjoy now lighting power. Additionally, the project has also assisted in the establishment of two power management committees, has completed the operation and maintenance of power supply stations, payment mechanisms and operational management; and has increased training and consciousness on residential electricity use.

The program provided a great educational and reading environment for school children, allowing the villagers to engage in economic activities such as night farming and helping to increase household's savings by reducing the purchase of candles or kerosene, and achieving the goal of inclusive growth and environmental protection.

Figure 7.2.3 Visiting the currently functioned weather stations in St. Christopher and Nevis

Source: The International Cooperation and Development Fund (TaiwanICDF)

Figure 7.2.4 Participated villagers of the Pilot Project of Myanmar Rural Micro-concentrated Power Supply Station took pictures with the installed solar panels

Source: The International Cooperation and Development Fund (TaiwanICDF)

Reference

1. Ministry of Science and Technology, Report of Office Operation (IV) Phase II of the National Energy Program (NEP-II), 2017
2. Ministry of Science and Technology, Report of Promotion and Management Project of Geothermal and Gas Hydrate Focus Center (IV) Phase II of the National Energy Program (NEP-II), 2017
3. Ministry of Science and Technology, Report of Sustainable Energy Technology and Strategy Development Application (IV) National Energy Program (NEP), 2017
4. Ministry of Science and Technology, Report of Promotion and Management Project of Offshore Wind Power and Marine Energy Focus Center (IV) Phase II of the National Energy Program (NEP-II), 2017
5. Ministry of Science and Technology, Report of Energy Technology Strategy Working Group (IV) Phase II of the National Energy Program (NEP-II), 2017
6. Ministry of Science and Technology, Report of Promotion and Management Project of Energy Conservation Focus Center (IV) Phase II of the National Energy Program (NEP-II), 2017
7. Ministry of Science and Technology, Report of Promotion and Management Project of Carbon Reduction and Clean Coal Focus Center (IV) Phase II of the National Energy Program (NEP-II), 2017
8. Ministry of Science and Technology, Report of Promotion and Management Project of Alternative Energy Focus Center (IV) Phase II of the National Energy Program (NEP-II), 2017
9. Ministry of Science and Technology, Report of Promotion and Management Project of Smart Grid Focus Center (IV) Phase II of the National Energy Program (NEP-II), 2017
10. Ministry of Science and Technology, Promotion and Management Project of Energy Technical Transfer and International Cooperation (III), 2018
11. Ministry of Science and Technology, Project of Energy Technology International Cooperation, Certification Research, and IP/ Techniques Industrialization Chain, 2018
12. Ministry of Science and Technology, Taiwan Integrated Research Program on Climate Change Adaptation Technology (TaiCCAT) –Climate Change Adaptation Technology Governance: Establishment and Application of Decision Support System (III), 2015
13. Delta Electronics Foundation, Project Introduction on 2017-2020 Building Micro-Climate Database. http://www.delta-foundation.org.tw/Project/29

▲Northeast Coast - Nanya

Chapter 8
International Cooperation and Exchange

Chapter 8
International Cooperation and Exchange

Taiwan has not yet become a part of the United Nations Framework Convention on Climate Change (UNFCCC) due to the international situation, governments at all levels in Taiwan have established multilateral and bilateral climate change cooperation with countries, from the central to local, industrial, academic to civic groups. Taiwan is integrated into global and regional cooperation networks to share Taiwan's efforts in the face of climate change and works with the international community to respond to climate change impacts and challenges.

8.1 Participation in UNFCCC

As a non-member to the United Nations, Taiwan is unable to sign the United Nations Framework Convention on Climate Change (UNFCCC) as a contracting party. However, Taiwan is proactively abiding by the implementation of the relevant international environmental conventions and the fulfillment of the obligations and responsibilities of the members of the international community. When the UN drafted the UNFCCC phase in 1991, Taiwan participated in the 3rd and 4th meetings of the Intergovernmental Negotiating Committee (INC) as an observer of the Non-Government Organization (NGO).

Since the 1992 Earth Summit, the 1995 UNFCCC First Conference of the Parties and its subsidiary bodies, Taiwan has continued to participate as a non-governmental organization. Nearly a dozen organizations have registered as UNFCCC NGO observers to participate in global climate activities.

Taiwan participates in UNFCCC's relevant meetings and promotes national climate policies in line with the progress of the conventions over the years. Taking the current principal Paris Agreement as an example, it fully grasps the development of fundamental issues as the objective for the country is to formulate policies and measures to adapt to climate change. After the implementation of the domestic greenhouse gas (GHG) reduction management law in the country, the legalization of Taiwan's climate policy will be exchanged and shared in the COP's field.

8.2 Exchange and Cooperation with Countries and Governmental Organizations

The impact of climate change transcends intercontinental and national boundaries. Therefore, international, regional and intergovernmental cooperation is adopted, taking into account the trend of international assistance, the needs of partner countries and regional development conditions. Taiwan advocates for national and inter-governmental climate cooperation and exchanges and continues to promote collaboration with businesses. Within the scope of financial and technical feasibility, Taiwan attaches importance to the quality of implementation of the cooperation plan and the benefits it brings, including social, economic or financial. We further monitor the continuity and sustainability of the execution of the plan.

This section introduces the principal projects of climate cooperation and exchange between Taiwan and other countries and governments. It is divided into four categories: lending and investment, technical cooperation, humanitarian assistance, and international education and training.

8.2.1 Lending and Investment

The international push for global climate action emphasizes the importance of funding, including the adoption of the UNFCCC's 16th Conference of Parties (COP), requiring developed countries to place at least $100 billion annually in global climate action by 2020. Article 9.1 of the Paris Agreement states that, "developed country Parties shall provide funds to assist developing countries in continuing their obligations under the Convention for mitigation and adaptation". Article 9.2 emphasizes on "encourage other Parties to voluntarily providing or continuing to provide such assistance." Taiwan recognizes the spirit of the Paris Agreement and actively promotes climate action and programs through investment and financing cooperation with friendly countries.

Take the brackets here as a full example of the International Cooperation and Development Fund (ICDF). The loans will be used to promote the development of public and private sectors, including public works, social development and agriculture development, financial intermediation and technical assistance to help AIA and friendly countries achieve their goal of steady and sustainable growth in economic and social development; and cooperate with international development partners to achieve financial leverage through cooperative financing to promote each project development plan. Among them, the finance related to climate change covers the areas of economic infrastructure and services, social infrastructure and services, and the production sector.

The area of economic infrastructure and services mainly assists the recipient countries in their sustainable economic development. The plan covers the construction of public infrastructure with disaster-resistant capabilities and the promotion of financial services to help the development of the private sector. The social infrastructure and service areas are designed to support recipient countries with developing human resources, improving environmental and public health conditions and promoting the living conditions of local people through such social welfare programs. Finally, in the field of the production sector, it mainly assists the development of the agricultural sector in recipient countries, such as improving the production efficiency of agricultural enterprises through financial services or funding farmers to cope with the impact of climate change.

There are two types of climate-related development projects: one is loan cooperation, the other is special fund type, and the latter refers to the establishment of funds in cooperation with international organizations for investment and financing projects in friendly or friendly countries. The following section highlights the key projects and cases promoted in recent years.

1. Loan

(1) The second phase of the social infrastructure design and painting of the Social Transformation Special Fund

The executive agency of the project is the Central American Economic Integration Bank, which aims to assist the highly indebted underdeveloped countries of Central America, including Nicaragua and Honduras, with preferential loans to carry out social transformation projects to meet the bank's goal of reducing poverty.

Under the plan, the Rural Infrastructure Project in Honduras is designed to meet the basic needs of people in the rural areas of Honduras by improving social infrastructures such as roads, sanitation water and electricity. The area covers the 9 provinces of Honduras, including assistance to beneficiaries in the planning and implementation of the project, rural infrastructure (roads, water supply and sewerage systems, electricity), and micro-loans with solar photovoltaic projects.

(2) Central America Regional Coffee Rust Loan Project

The project implementation agency is the Central American Economic Integration Bank, which aims to assist the Central American government and the country's coffee small farmers to obtain funds for coffee rust prevention and control. The project also receives the technical assistance grants provided by the Ministry of Foreign Affairs and the Central American Economic Integration Bank. As the goal is to recover the coffee production before being severely affected by diseases related to climate change and improving the income of coffee farmers, the project includes two major projects: “Agricultural Loan” and “Technical Assistance”.

The implementation of the “Agricultural Loan” in this project is planned by the Ministry of Agriculture of the beneficiary country according to the coffee rust status and the demand for coffee small farmers. Then, it is submitted to the plan execution agency for review and approval by the Central American Economic Integration Bank. The cooperation unit of our country is invited to start implementation. There are two uses for loan funds:

1. Plant Renewal: Assisting small coffee farmers to obtain funds to replace old plants that are susceptible to diseases, to rehabilitate disease-resistant varieties and to provide funds for small farmers to renew their plants and lack the income during their income.

2. Field management assists small coffee farmers to obtain funds for strong pruning, rust prevention in the infected coffee field and to provide funds for life during the period of smallholder income reduction.

(3) Marshall Islands Household Energy Efficiency and Renewable Energy Project

The Marshall Islands Government established the National Energy Policy and the Energy Action Plan in 2009 to improve its people by providing clean, reliable, affordable, friendly environments and sustainable energy services. The quality of life, while diversifying energy pipelines, strengthens the country's energy security. To implement the aforementioned energy policy, Marshall Islands has set a goal of achieving 20% of the country's total power generation by renewable energy generation and improving household energy efficiency by at least 50% by 2020.

The Marshall Islands relies on imported energy to reach more than 90% of its energy supply, while solar energy only accounts for 1% of its supply. The most notable power consuming sectors in the Marshall Islands include commercial, family and government users. Households use the highest proportion of electricity. Therefore, the project is targeted at home users. The project is aimed to increase the proportion of renewable energy generation in the Marshall Islands through household energy improvement programs.

Therefore, the plan aims to reduce the energy consumption of Marshall and plan to replace some fossil fuels with renewable energy to reduce the dependence of Marshall Islands on imported energy. The project includes energy efficiency and renewable energy projects. The actual implementation agencies include Marshall Development Bank (MIDB) and Marshall Power Company (MEC).

Therefore, the plan aims to reduce the energy consumption of the Marshall Islands and plans to replace some fossil fuels with renewable energy to reduce the dependence of the Marshall Islands on imported energy. The project includes energy

efficiency and renewable energy projects. The actual implementation agencies include Marshall Development Bank (MIDB) and Marshall Power Company (MEC).

Beneficiary households will apply for loans directly from the Marshall Development Bank. The use of loan funds includes replacing energy-consuming household appliances and lamps as well as updating old routes, improving household energy efficiency and installing household solar photovoltaic systems. Applicants must first conduct an energy audit by Marshall Power Company to review the electrical equipment that should be replaced and confirm whether it is cost-effective. The Marshall Development Bank will apply for the loan according to the credit policy of its consumer loan. The same applies to solar systems.

After obtaining funds from the Ministry of Finance, the Marshall Development Bank is responsible for lending the funds to eligible household loans for the aforementioned project. Marshall Power is responsible for technical support and the Marshall Islands Energy Office is responsible for coordination between government agencies. The project further estimates the subsequent environmental benefits. The energy efficiency and renewable energy projects promoted by the Marshall Islands National Plan have achieved carbon reduction efficiently. The meeting was held during the 2016 UNFCCC COP23 in Bonn, Germany. The government has jointly shared the expected carbon reduction contribution and bilateral cooperation model of this project with the international community for the first time.

2. Special Fund

(1) European Bank for Reconstruction and Development (EBRD) Special Investment Fund Small Business Account.

The executive body of this case is the European Bank for Reconstruction and Development (hereinafter referred to as the European Bank). In line with the overall foreign policy of the government, it assists the development of friendly financial institutions in Central and Eastern Europe, the Western Balkans, Central Asia and the Independent National Association to strengthen the financing channels for small and medium-sized enterprises, to develop the private sector to achieve the national transformation goals of the region. To achieve the above objectives, the International Cooperation Development Fund established the “Special Fund for Financial Intermediary and Private Sector Enterprise Investment” at the European Bank. The European Bank promoted the sub-plan in the list of designated countries in the association and provided financing to financial institutions. They further eased re-lending to small medium-sized companies or borrowers of the Green Economy Financing Facilities. The purpose of the green economy financing mechanism is to promote the development of the green economy market, solve the market barriers of financing green technologies and products, and drive private sector investment in energy, resource sustainability and climate recovery plans.

For example, the “Romania Green Economy Financing Facility” program, in which the association has participated in, has provided financing to the Participating Financial Institutions (PFIs) for funding sustainable projects. The investment plan for energy residential or construction is addressed to individuals as well as for groups, housing associations, management companies, related service companies and equipment vendors. The purpose of the funds is to support investment in energy housing or constructions such as energy-saving windows, insulation on wall roofs or floors, solar water heaters, solar panel installations, heating systems and heating systems

and energy-efficient appliances that achieve at least 20% energy efficiency.

The transformation benefits expected to be achieved in this project include: demonstrating the potential of green technology and service investment market, transferring technology, services and knowledge of green transition economy, and improving information asymmetry and capacity limitation of green loans.

(2) European Bank for Reconstruction and Development (EBRD) Green Energy Special Fund

In view of a large number of development plans for the environmental protection category, when the European Bank introduced the Sustainable Energy Initiative (SEI) in 2006, the representative office of the United Kingdom began to pay attention to the opportunity to explore collaboration. Silver's overall plan for SEI was to establish a "European Bank Green Energy Special Fund" in assistance with Euro Bank in 2011. According to the Green Energy Special Fund Regulations adopted by the Bank of Europe, the Bank of Europe acts as the manager through its headquarters and resident. A network of offices is then in charge of exploring, evaluating and promoting various programs.

This case will anticipate the reduction of the CO_2 emission rate and the interest rate of the loan while using this innovative financial instrument to establish a positive incentive to encourage the beneficiary governments to improve their willingness to adopt the best green energy technology when promoting municipal infrastructure. In the early stage of the project, it may cooperate with the Ministry of Foreign Affairs' technical cooperation grant to lock in solar photovoltaic, LED street lights or traffic signs, renewable energy and other related projects, and increase the participation opportunities of experts in Taiwan's related fields. Currently, it has been signed in 6 municipalities. In the Green Energy Infrastructure Project, the three existing neutron projects include the LED streetlight construction project in Kirchnev, Moldova, the solid waste project in Greater Amman, Jordan and the Na Elektrokrajina distribution system update program in Bosnia and Herzegovina.

8.2.2 Technical Cooperation

Based on the national development strategies and objectives of partner countries, Taiwan has carefully analyzed the challenges and bottlenecks faced by these countries in the development process through detailed planning, preparation and consultation, and formulated the "capacity construction" and "technology transfer" strategies. The core technical cooperation program is mainly focused on assisting partner countries to overcome technical gaps and enhance added value through expert consultation, technical training, functional enhancement or business coaching, and thus improving people's living standards. This report has included the case of technology transfer in Section 7.2. This section also focuses on the "Taiwan Environmental Protection Technology Cooperation Agreement".

On June 21, 1993, the Taipei Institute of Economics and Culture and the American Association of Taiwanese Associations signed the "Agreement between the American Institute in Taiwan and the Taipei Economic and Cultural Representative Office in the United States for Technical Cooperation in the Field of Environmental Protection", in which the implementation units are the Executive Yuan Environmental Protection Administration, ROC Taiwan and the US Environmental Protection Agency. The agreement was extended five times in 1998, 2003, 2008, 2013 and 2017, with an extension until June 2023.

Under this agreement, the bilateral EPA will establish an implementation practice in two or three years. Under this approach, the two- or three-year plan implementation activities will be agreed upon by both parties. Over the years, under the framework of the agreement, the companies have successfully introduced advanced pollution prevention technology and environmental management experience in the United States. Many of these are related to climate policy and action, including the introduction of the US Energy Star Program, energy engineering related model research and exchange, GHG reduction, watershed management, waste management, toxic chemical substance management, risk assessment, regional air quality monitoring and forecasting mode or monitoring equipment, among others, for the construction of Taiwan's environmental protection management policies and capabilities, and the introduction of environmental quality technology, A significant improvement was met.

To enhance the ability to estimate GHG emission trends and evaluate GHG strategies, Taiwan has invited experts from the US Department of Energy's Brookhaven National Laboratory (BNL) to come to Taiwan for energy engineering model (MARKAL) experience. Their meetings have been based on issues related to Exchange, assistance in updating and expanding Taiwan's MARKAL model analysis function to assess the energy-environment-economic impact of Taiwan's GHG reduction target and assistance in calibrating and strengthening the Taiwan MARKAL model database, including the establishment of GHG reduction technology data, industrial structure changes, in the case of industrial energy service demand estimation methods.

Facing an uncertain future, the carbon reduction strategy has to be multi-faceted and multi-level development. Conducting model simulation exchanges with BNL, strengthening the analysis capability of Taiwan's MARKAL model and implementing policies such as the industrial development reduction strategy under the GHG reduction target are measures needed to achieve the success of this strategy. The ability to model the structure and case analysis to systematically explore the impact of various uncertainties on strategy choices and make an in-depth analysis of important decision-making factors is required as a reference for Taiwan's future prediction of GHG emissions and the assessment of GHG emissions strategies.

On August 11, 2011, the bilateral environmental protection directors met in Washington DC to reach a consensus on jointly promoting regional partnerships. These agreements were included in the implementation plan No. 9 and expanded by the bilateral project plan from 2011 to 2013. Cooperation with regional and international organizations, emphasizing good government environmental governance and collaboration with enterprises and communities has produced partnerships that include countries, regions and cities. Partners also involve primary and secondary schools and communities at the grassroots level, deepening both sides and regions inclusiveness. At the partnership level, we will exert collective strength to jointly safeguard regional environmental quality to protect human health.

Between 2014 and 2015, the EPA worked with the US Environmental Protection Agency on the Pan Pacific Adaptation on Climate Change (PPACC) to conduct the Pan-Pacific Pacific Climate Change Adaptation International Symposium to provide climate change adaptation. The exchange of governance experiences has come from 10 countries, 4 international organizations, and 28 representatives from the public and private sectors jointly plan

specific climate partnership cooperation models and platforms.

8.2.3 Humanitarian Assistance

The Intergovernmental Panel on Climate Change (IPCC) released in 2018 the "1.5 °C Global Warming Special Report" based on scientific facts and evidence to appeal to the international human society. At the present carbon discharge rate, the planet will reach a temperature rise of 1.5 °C after 10 to 12 years. At that time, the negative impact of climate change and the cost of disasters will become very high.

In more common situations, the impacts and losses caused by extreme climate events and slow-moving events because of climate change are facing difficulties to adopt successful mitigation and adaptation actions. For this reason, the UNFCCC adopted the resolution on “loss and damage” at the 19th Conference of the States Parties. The Loss and Damage Mechanism, under the Article 8.1 of the Paris Agreement, states that “Parties recognize the importance of avoiding, minimizing and addressing the adverse effects associated with the effects of climate change (including extreme weather events and slow-onset events), as well as the effects of continued development without reducing losses and damage."

In response to the loss and damage caused by climate change, and in terms of international assistance and cooperation, Taiwan provides help to friendly developing countries affected by natural disasters and climate change. Furthermore, Taiwan can provide support for local disaster relief or reconstruction, humanitarian crisis and respond to the local standard of living as soon as possible. The following is a list of key assistance and cooperation programs of the International Cooperation and Development Fund (ICDF) in recent years, as shown in Table 8.2.1.

Table 8.2.1 International Cooperation and Development Fund (ICDF)'s key programs of humanitarian assistance and international cooperation in recent years

Country	Program	Cooperative Organization	Term	Program Summary
Honduras	Honduras Dry Corridor Community Disaster Resilience Enhancement Program	CARE Honduras	106/12/08 ~ 107/11/07	Dry Corridor in the southern part of Honduras faces a drought crisis all year round. In recent years, climate variability has seriously affected the basic survival of vulnerable communities in the region. The project helps region suffered from drought by improving the knowledge and skills of community residents in climate change-related risk management, improving the ability of the Community Emergency Response Committee to monitor and forecast droughts, and setting up small water-related infrastructure. Community to improve disaster resilience.
Nepal	Food Safety and Livelihood Enhancement Program in Gork County, Nepal	CARE Nepal	105/12/01 ~ 106/11/30	In response to the strong earthquake striked Nepal in 2015, the "Gurkey County Food Security and Livelihood Support Program" was completed on November 30, 2016. In view of the good performance, it will continue. The project strengthens the food security and livelihoods of 1,800 vulnerable households affected by the earthquake through agricultural technology capacity building, semi-commercial production support and micro-enterprise support.
Nepal	Nepal Health Station Reconstruction Project	World Vision	104/12/09 ~ 106/03/08	On April 26 and May 12, 2015, strong earthquakes in Nepal caused most health stations to collapse and be damaged. They could not play their proper functions in diagnosis and treatment and health education, and also increased people's medical difficulties. The project assisted five villages in four counties of the earthquake-stricken areas to rebuild four health stations and one clinic with earthquake resistance, and strengthen community and health personnel knowledge of post-disaster health, disease and disaster risk management, and The management of disease outbreak management, disaster prevention and, drinking water, sanitation and personal hygiene to provide victims with more quality health care services.
Nepal	Food Security and Livelihood Support Program in Gorkha County, Nepal	CARE Nepal	104/12/01 ~ 105/11/30	On April 26 and May 12, 2015, strong earthquakes in Nepal caused more than 100 million US dollars of losses in Nepal's agriculture, including 130,000 tons of food and reserve food, livestock and agricultural tools. Gurkha County is one of the hardest hit areas. The project aims to assist at least 850 vulnerable households affected by the earthquake to restore basic livelihoods; and provide farming training, strengthen market linkages in targeted areas, improve market mechanisms and strengthen community resilience to maintain food security.
Solomon Islands	Solomon Islands Flood Disaster Health Plan	World Vision	103/12/01 ~ 105/05/31	In April 2014, the province of Guadalcanal in the Solomon Islands suffered severe floods, affecting 52,000 people, floods public facilities and residents' property, deriving public health and people's livelihoods, causing diarrhea, acute respiratory infections, etc. due to poor water hygiene. The resulting cases have soared. The project assisted 1,335 people in 12 affected communities through health promotion, water system restoration and animal fences to gain the capacity and resources to respond to health and health issues.

Country	Program	Cooperative Organization	Term	Program Summary
Philippine	Philippine Haiyan Typhoon Recovery Program – Health Center Redevelopment Project	World Vision	103/06/1 ~ 104/4/30	Typhoon Haiyan invaded the Philippines on November 8, 2013 and caused severe disasters. Leyte Province is one of the hardest hit areas, most of which are located in the grassroots health stations in the village. Due to the large loss of health personnel after the windstorm, and the lack of medical supplies such as measuring or medicines. In the case, the operation is quite difficult. Local community residents are unable to get proper medical services, and the number of infectious diseases has increased (such as acute respiratory tract, diarrhea and skin diseases), and the situation of vulnerable groups such as women and infants will be more difficult. The project will increase the capacity of 511 community medical personnel in the Leyte province of the Philippines and provide support for 18 primary health stations (such as equipment and medicines), thereby restoring the local primary medical services and enabling local people to obtain good basic medical care.
Haiti	Haiti Hurricane Sandy Cholera Emergency Prevention Plan	World Vision International, Haiti	102/02/01 ~ 102/07/31	Haiti was hit by Hurricane Sandy in late October 2012, causing major disasters that destroyed nearly 7,000 homes in Haiti, leaving more than 30,000 homeless. After the hurricane, the number of cholera infections increased rapidly, the local public health situation was horrible, the mortality rate continued to rise and the disease spread. The project aims to assist local victims and relieve cholera epidemics by immediately investing in medicines, distributing clean drinking water and providing relevant public health services.
Haiti	Haiti New Hope Village Water Supply Project	Red Cross Republic of China	102/01/01 ~ 102/12/31	In order to assist the 200 residents of the "New Hope Village" built after the 2010 earthquake in Haiti to solve the problem of water use for the people's livelihood, the project will establish a river block in the neighboring L'Attalaye River to send water to the New Hope Village, eliminating the local The time for residents to pick up water every day. In addition, the water supply channel will flow through the reclamation area and will be equipped with field irrigation channels to irrigate about 50 hectares of agricultural land to improve agricultural production efficiency.

Source: International Cooperation and Development Fund (ICDF)

Table 8.2.2 List of ICDF's workshop on environmental protection related issues from 2016 to 2018

Year	Class	Workshop Summary
2016	Climate Change and Natural Disaster Management Workshop	Sharing Taiwan's response to global climate change and its experience in preventing and monitoring natural disasters caused by climate change, the course is based on the "General Introduction to Climate Change" and "Disaster Risk Management", in addition to analyzing Taiwan's strategies and practices in response to climate change. And further explore the prevention and management of disasters caused by climate change, and enable participants to understand Taiwan's response to climate change and international participation experience as a reference for the participating countries to promote relevant policies in the future.
2016	Climate Change and Natural Disaster Adaptation Workshop (Island States Class)	In recent years, climate change has had a dramatic impact on the world. In particular, the countries of the South Pacific and the Caribbean are more vulnerable to the environmental vulnerability of island countries. The workshop will plan the dual-focus course of "General Introduction to Climate Change" and "Natural Disaster Adaptation Strategy" for the current situation of most island countries, so that island-based friends and friendly countries can understand the adaptation strategies of natural disasters caused by climate change. How to work with other countries through environmental governance models to minimize disasters.
2016	Solar Photovoltaic Business Workshop (ASEAN and South Asia Special Class)	This class shares the current status and experience of Taiwan's solar photovoltaic development from the two aspects of "Sun Optoelectronics Development Technology" and "Applying Solar Photovoltaic Industry Value Added", and cooperates with Sun Optoelectronics to manufacture standard manufacturers and solar photovoltaic value-added industry demonstration sites. Let the trainees understand the current development and application trends of solar photovoltaic technology, and promote potential business opportunities.
2017	Sustainable Disaster Prevention Community Workshop (Central and South America, Caribbean and Asia Pacific)	This class aims to share the successful experience of the Taiwanese community's sustainable and independent disaster prevention with friendly countries in Central and South America, the Caribbean and the Asia-Pacific region, and to introduce technology and equipment resources through the discussion of disaster prevention industry exchanges to create potential business opportunities in the future. The course is based on the "Community Sustainable Disaster Prevention International Trends and Taiwan's Strategic Planning", "Persistent Disaster Prevention Practices" and "Sustainable Disaster Prevention Technology Management and Application". The topics include "Global Climate Change and Citizen Participation", " Taiwan's sustainable development strategy in response to climate change, "complex disaster management (preparation, response and reconstruction)" and "establishment and operation of regional self-reliant communities in Taiwan", through lectures, visits, exchanges and reports, etc. The trainees will be fully educated in order to provide a reference for the disaster prevention system that is suitable for their home country and is feasible after returning toTaiwan.
2017	Clean Energy Development Strategy Workshop	This class aims to introduce Taiwan's strategic plan for developing clean energy, and to introduce in depth the equipment, operation mode and standard testing process of clean energy law, clean energy (solar, wind, water, tide, etc.) and share the industrial application of clean energy technology. To facilitate students to understand the current status and future trends of clean energy development, and through lectures, visits, exchanges and reports, etc., to enable students to participate in the training and return to the country to develop a suitable and feasible clean energy development suitable for their home country. Strategy.
2018	Smart Water Application and Management Workshop	Taking "Smart Operation Management" and "Smart Technology Application" as the main axis, we will share the concept of smart water use, management and execution with the participants. In addition to sharing the experience of Taiwan's application communication and Internet of Things (IOT) technologies in water control, flood control, siltation prevention and water quality monitoring, and adopting intelligent water resources management methods, the development of a climate-resilient water management system and a new model of water conservancy industry, Through the multi-sustainable water resources management system to solve water resources problems, it also introduces Taiwan's use of the Internet of Things, big data, capital communication technology and cross-domain integration and utilization capabilities to drive production, government and academic circles to accelerate the development of water, energy and energy. Water treatment for valuable resource recovery, smart monitoring and emerging instruments.

Source: International Cooperation and Development Fund (ICDF)

8.2.4 International Education and Training

Taiwan plans various professional workshops. For example, the ICDF has established an "International Higher Education Cooperation Strategy Alliance" in cooperation with national universities, which handles all scholarships for universities and master's degrees taught in English. It incites national universities to participate in international development cooperation channels. Additionally, they also actively handle or collaborate with international organizations to manage a number of educational training programs and deliver the vision of assisting partner countries to cultivate talents and sustainable development.

1. Workshop on environmental protection related issues

Taiwan is an island country. The strategies and practices used for many years in response to natural disasters caused by many climate changes can now be used for other friendly island-nations to adapt to climate change and disasters. Since the beginning of the year, the ICDF has held seminars on environmental protection related issues to assist friendly countries with professionals fostering to develop the ability to control climate change and natural disasters. The workshops plan different themes every year and invite the Ministry of Science and Technology, the Environmental Protection Administration, the Council of Agriculture, the Central Weather Bureau, the National Centre of Disaster Reduction and other experts from relevant fields in domestic universities to hold lectures. The workshops on environmental protection related issues from 2016 to 2018 are shown as Table 8.2.2.

2. United Nations Framework Convention on Climate Change (UNFCCC) NGO Forum

Taiwan has participated in the conference since the first UNFCCC COP. Furthermore, the Taiwanese civil society is also deeply rooted in the UNFCCC. To strengthen the communication between Taiwan's environmental NGOs and UNFCCC's NGO observers since 2013, the Ministry of Foreign Affairs has hosted the UNFCCC NGO Forum, inviting the NGO observer constituency to contact representatives or organizations to participate in the forum to discuss climate cooperation. The theme of each year forum is shown in Table 8.2.3.

Table 8.2.3 List of Ministry of Foreign Affairs (MOFA)'s UNFCCC NGO theme summary from 2013 to 2017

Year	UNFCCC NGO Theme Summary
2013	Inviting representatives from the Women and Gender CC and the Research and Independent Institutions (RINGO) were invited to discuss the topic "How to Strengthen NGO Participation in the UNFCCC Process".
2014	With the theme "The Role of NGOs in the Post-2015 Kyoto Agreement Process", representatives of the Women and Gender CC and the Youth Organization (YOUNGO) were invited to discuss.
2015	With the theme "Joint and Practice: The Power of NGOs in New Global Governance", representatives from the Women and Gender CC and the Indigenous People Organizations (IPO) were invited to discuss.
2016	With the theme of "Challenging and Adapting: Towards the Future and Coexisting with Climate Change", the ambassador of the Friends of the State of Taiwan and several foreign experts and scholars were invited to discuss.
2017	With the theme of "International Conference on Livable Cities towards Sustainable Development", MOFA cooperated with Taichung City's "International NGO Operation Center" to set up related activities and invite international NGOs and local governments to organize discussions.

Source: Ministry of Foreign Affairs (MOFA)

8.3 Exchange and Cooperation with Local Governments & Cities

8.3.1 International Council for Local Environmental Initiatives, ICLEI - Local Governments for Sustainability

The International Council for Local Environmental Initiatives, ICLEI - Local Governments for Sustainability was established in September 1990 in New York, when the United Nations convened the world conference on the sustainable future of local governments. The current membership includes 86 countries. 12 megacities, 100 super cities and metropolitan areas, 450 large cities and 450 small and medium-sized cities and towns. In total, more than 1,000 local governments become members, establishing ICLEI as the world's largest international network of commitments to the organization of sustainable development.

A total of 11 cities in Taiwan have joined ICLEI: Taipei, New Taipei, Taoyuan, Hsinchu, Taichung, Yunlin, Chiayi, Tainan, Kaohsiung, Yilan and Pingtung. In recent years, Taiwan has vigorously promoted energy conservation and carbon reduction policies and specific actions, which have achieved concrete results under the efforts of local cities and their citizens. In addition to actively constructing the legal basis for climate change, it fully demonstrates Taiwan's determination to save energy and reduce carbon emissions. Furthermore, through the selection process of low-carbon demonstration cities, governments at all levels fully understood the low-carbon perceptions and thinking, and now are studying the concept of low-carbon urban development. The Environmental Protection Administration of the Executive Yuan has repeatedly invited ICLEI experts to visit Taiwan to share the strategic practices and successful experiences of ICLEI in promoting low-carbon city partners around the world. It is expected to enhance the capacity building of local cities in response to climate change and promotion of sustainable urban development by building low-carbon homes.

Taiwan's geographical location in the center of Asia led to ICLEI's establishment in Taiwan, under the Kaohsiung City Government's successful bid to establish the "ICLEI Kaohsiung Environmental Sustainability Training Center in East Asia" in 2011 (ICLEI Kaohsiung Capacity Center, ICLEI KCC), which began operations in September 2012. Additionally, it eases the implementation of the tasks of the ICLEI World Secretariat and supporting offices in East Asia, provides information exchange and education centers for member training, professional knowledge and a variety of environmental sustainability policy management services. It further promotes exchanges and cooperation in international low-carbon cities, expands international exchanges in low-carbon cities and demonstrates Taiwan's determination and vitality to create a low-carbon home.

8.3.2 CityNet

The international organization CityNet is an urban organization dedicated to the sustainable development of the Asia-Pacific region. It was established in 1987 with the support of UNESCAP, UNDP, UN-HABITAT. Headquartered in Seoul, Korea, it currently has 88 full members, 49 associate members and 1 corporate member. Additionally, there are 20 other multilateral, bilateral, regional and international organizations, such as the United Nations Economic and Social Council, UNESCO, Asian Development Bank, Japan International Cooperation Agency, Cities and Local Government Alliance and

World Bank, to jointly support the operation and development of the organization.

By creating a knowledge exchange platform and promoting urban cooperation and tangible projects, the city network helps members take the challenges in climate change and natural disasters while strives for sustainable urban development. There are three cities from Taiwan participating in the initiative, including Taipei City, Taichung City and Kaohsiung City. Taoyuan City also evaluated the feasibility of joining the organization in 2019. Taipei City began to participate in the city network activities from 2004 to 2005. In September 2016, it hosted Taiwan's first global urban network disaster group meeting and cooperated with Yokohama City of Japan to launch disaster response cooperation in Asian cities.

8.4 Exchange and Cooperation with Non-Government Organizations

8.4.1 Business and Industry NGOs

1. Air Industry and Shipping Industry

Taiwan's aviation industry dominantly participates in ICAO and IATA carbon reduction policies and international cooperation in response to international cooperation and exchanges on climate change issues. One particular case is the Pacific Greenhouse Gases Measurements Project (PGGM), which is operated by China Airlines and Evergreen. It is supported by the National Science Council and the Environmental Protection Agency and is implemented by the Central University to build the world's largest air and air offshore GHG observation platform.

China Airlines cooperated with the European Union's "Global Greenhouse Gas Commercial Aircraft Observation Program" to load the In-Service Aircraft for a Global Observing System (IAGOS) on the A340-300 passenger aircraft numbered B-18806. The vehicle was officially put into operation on June 26, 2012, making China Airlines the first airline in Asia to implement IAGOS, the second airline in the world after Germany Airlines and the world's first IAGOS vehicle to collect Pacific high-air data. The collected results have also contributed to the World Meteorological Organization (WMO) research as a reference for decisions related to the UN Framework Convention on Climate Change. The global GHG commercial aircraft observation program route is shown in Figure 8.4.1.

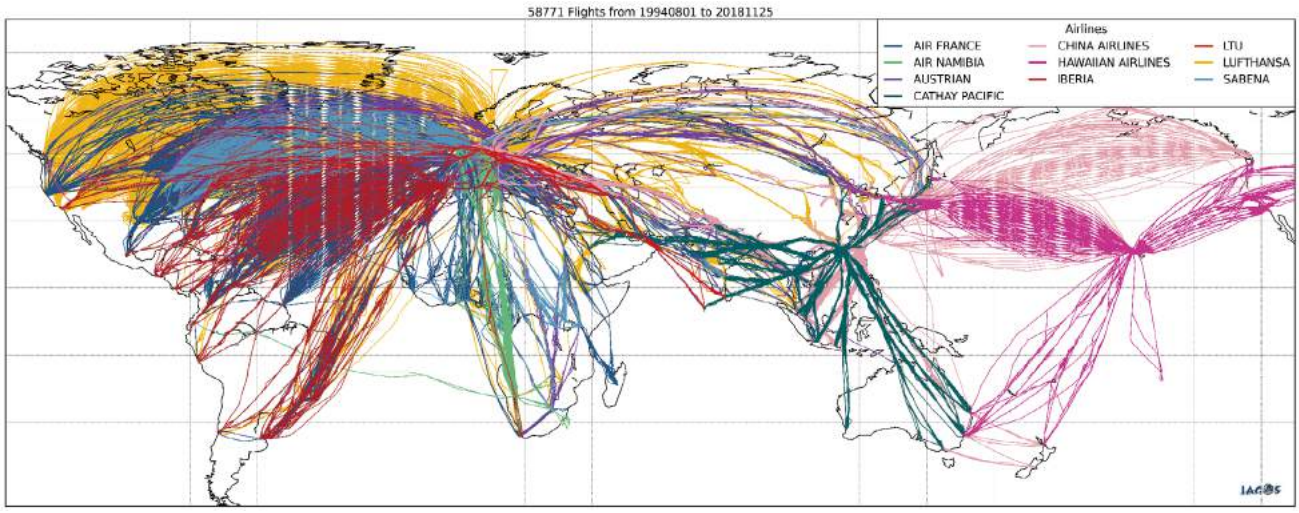


Figure 8.4.1 The global greenhouse gas commercial aircraft observation program route

Source: China Airlines

The A340-300 passenger aircraft numbered B-18806 was decommissioned in June 2017 (see Figure 8.4.2). Due to the outstanding performance of IAGOS, two A330-300 observatories were added in July 2016. China Airlines, the first airline in Asia to observe the Pacific climate with a two-machine aircraft and expand its scope to Oceania, has helped academic institutions to save about NT$1.4 billion in aircraft flight costs each year, demonstrating the corporate social responsibility of actively contributing to international environmental protection.

Evergreen Marine has sailed for EVER ULTRA since 2009, collecting maritime observation platforms for marine boundary data. It has realized the first voyage to observe the international seas, providing observations of the ocean boundary layer below 100 meters and continues to provide three years of observational assistance to understand global warming and global climate change research. The observation instruments of the freighter are partly manufactured by the National Central University and partly cooperated with the University of Cambridge in the United Kingdom. All instruments have been used for more than 10 years.

This research project integrates the global water vapor observation data of Taiwan's Formosa Satellite 3 and the sea level observation data of the Evergreen Ocean freighter, which will help to understand the concentration changes of GHG in the Pacific in the next 10 years and 20 years through a set of three-dimensional spatial distribution data of GHG in the Pacific.

Figure 8.4.2 China Airlines loads the global observing instrument system on the A340-300 passenger aircraft

Source: China Airlines

2. Steel Industry

Taiwan's steel industry actively participates in the World Steel Association's carbon reduction policies and actions. While assisting the association to collect GHG emissions data from major international steel mills, Taiwan's steel industry has established a technical database of emissions and reductions in the steel industry, expecting to reduce carbon emissions globally. Taiwan's steel industry also serves as the representative of the South-East Asia Iron and Steel Institute (SEAISI) Environmental Safety and Health Committee, further supporting the promotion of Southeast Asian steel technology and environmental safety and security service. Additionally, it is actively assisting neighboring steel industry to maintain good interaction and cooperation with regional industries, technology development and policy information, as a good foundation for business development and strategic cooperation. Moreover, Sinosteel also cooperated with the Ministry of Economic Affairs of Taiwan to participate in the OECD Steel Committee related to industry and environmental information exchange.

3. Semiconductor and Electronics Industry

Taiwan Semiconductor Industry Association (TSIA) has been actively involved in the World Semiconductor Council (WSC) since 1998. The organization comprises of the United States, Europe, Japan and South Korea and Taiwan. TSIA's activities on fluoride reduction were agreed in 1999 to reduce fluoride emissions by less than 90% of the base year by 2010. In 2000 the base year for fluoride exposure was 1998* (1997 the average of emissions in two years compared with 1999). In addition, TSIA also signed a Memorandum of Understanding (MOU) with the Environmental Protection Administration of the Executive Yuan in 2005, committing itself to the goal of reducing fluoride emissions. As of 2017, Taiwan's fluorine gas reduction in WSC is the same as Japan's and the fluorine tail gas removal rate is close to 90%. In addition to the literature contribution of the 2006 IPCC National Greenhouse Gas Inventory Guidelines, Taiwan also participated in the 2019 Update of the IPCC Guidelines for National Greenhouse Gas Inventories (hereinafter referred to as the 2019 IPCC Guidelines).

The Taiwan TFT LCD Association (TTLA) is also actively participating in The World Display Device Industry Cooperation Committee (WDICC), which consists of four members: TTLA, Japan Display Equipment Industry Committee (JDDIC), Korea Display Industry Association (KDIA) and China Optoelectronic Display Association (CODA). Taiwan's industry led in 2004 in activities on fluoride reduction and signed a Memorandum of Understanding (MOU) on the cooperation of reduction with the Environmental Protection Agency of the Executive Yuan as an entity committed to the goal of reducing fluoride emissions. In the past 20 years, TTLA has reduced about 40 million tons of CO_2eq GHG. The fluorine exhaust gas destruction removal rate has exceeded 90% and many panel industry parameters in the 2019 IPCC guide refined version are provided by the association member companies.

4. Business and Industry Alliance

Taiwan Institute for Sustainable Energy (TAISE) has been a member of UNFCCC NGO Observer since 2009 and has continuously participated in the Conference of the Parties. It has also collaborated with professional research institutes, such as the UK Transport Research Foundation and the Industrial Technology Research Institute (ITRI), to host several side events. TAISE has been in charge to share our practical experience in implementing low-

carbon electronic metering charges, green energy and environmental recycling. The Foundation held a climate leadership training camp from 2009 to 2011, led the selection of young ambassadors to attend the conference and in 2017 continued to train youth ambassadors to participate in UNFCCC COP 23.

8.4.2 Research and Independent NGOs

The Industrial Technology Research Institute (ITRI) is the first non-governmental organization observer in Taiwan to have been approved by the UNFCCC. Over the years, it has been involved in the issue of low-carbon technologies such as energy efficiency, renewable energy and smart grid, while striving for a future of innovation. As a member of the International Emissions Trading Association, ITRI has participated in the activities of the Association; has joined the UNFCCC Independent and Research NGO (RINGO) and has observed the dynamic progress of the UNFCCC issues in the long term.

8.4.3 Environmental NGOs

In 2014, the Delta Electronics Foundation held its first side event in UNFCCC COP20 in Lima, Peru, to share the experience of rebuilding the small green building in the Namasia Ming Quan Elementary School. At UNFCCC COP21 in Paris, the Foundation displayed "Delta21 Green Building- Delta Green Building Special Exhibition", "Perpetual Innovation Forum" and "Delta21 Green Building Forum" at the Grand Palace. The Foundation received an invitation from the Local Government Sustainable Development Council (ICLEI) to share with the private sector role in assisting the city to promote sustainable development at the surrounding conferences, with the participation of Toyama, Japan, Ulaanbaatar, Mongolia, and Shenzhen, China. Furthermore, international city decision-making executives such as New Taipei City, the Asian Development Bank and climate experts exchanged ideas and emphasized on energy conservation potential in both construction and transportation.

The Environmental Quality Protection Foundation (EQPF) promotes environmental education in Taiwan for the UNFCCC COP and promotes people's awareness in correct environmental issues and cares while monitoring government environmental policies to participate actively in environmental decision-making. The EQPF participates in the discussion of environmental issues, including climate change, climate policy and legal system, water conservation, waste disposal, biodiversity and low carbon consumption. Since 2006, the company has regularly organized a delegation to participate in the COP and a peripheral meeting with the International Environmental Education Organization to promote climate education materials at the exhibition booth.

Figure 8.4.3 Delta Electronics Foundation's Green Building Exhibition at the Grand Paclace Paris in COP21 2015

Source: Delta Electronics Foundation

8.4.4 Women and Gender CC

Taiwan's NGOs participate in the UNFCCC COP and actively cooperate and interact with the Women and Gender CC, which are the Foundation for Women's Rights and Interests Development Foundation, the Women's Alliance Environmental Protection Foundation and the mothers who joined the Convention NGO in 2017 that oversee the nuclear power plant alliance. In recent years, the most in-depth experience of Taiwan's gender and women's organizations participating in COP was in the 2015 COP21 Paris Conference.

The Foundation for Women's Rights and Interests Development held a conference at the COP21 venue under the title "Challenging Stereotypes: Women's Use of Communication Technology for Innovation Participation in Climate Change Issues", including WECAN International, International Medical Students Association (IFMSA), Peruvian NGO Pachamama's Path Representatives from the Industrial Research Institute, the Housemaid Coalition Environmental Protection Foundation, the Lima Taiwan Aboriginal Youth Working Group and the Swedish Sami

Figure 8.4.4 Environmental Quality Protection Foundation (EQPF) staff at the COP booth

Source: Environmental Quality Protection Foundation (EQPF)

Parliament. The conference discussed three topics: (1) how to incorporate a gender perspective on climate change issues; (2) How to make good use of innovative technology and cooperation between the public and private sectors to strengthen the resilience of the disadvantaged groups; (3) Community mothers and indigenous women's local environmental protection wisdom sharing.

In the case study of the Housewives Alliance Environmental Protection Foundation and the Lima Taiwan Aboriginal Youth Working Group, the event successfully promoted the experience of Taiwanese

community mothers and Aboriginal women to international occasions and received repercussions, calling for women to be in the field of climate change, further remarking the importance of participation in Taiwan in these conferences.

8.4.5 Youth NGOs

Taiwanese youth participate in the international issue of climate change with The Taiwan Youth Climate Coalition (TWYCC) being the most important. Since 2009, the organization has participated in the COPs. In 2010, it joined the UNFCCC youth NGO constituency YOUNGO. In 2012, youth from East Asia jointly established the Asian Youth Climate Network (AYCN). In 2013, members of TWYCC were selected as the focal point between the YOUNGO and the Convention Secretariat. With the Paris Agreement entry into force and in line with the Paris Agreement Global Stocktake related policies, TWYCC launched the Taiwan Youth Climate Stocktake Campaign in 2017 to supervise the Taiwan government's commitment to improve the climate policy and to examine the effectiveness of Taiwan's INDC implementation with international standards.

Figure 8.4.5 Taiwan Youth Climate Coalition (TWYCC) activiely participates UNFCCC YOUNGO's training workshops and actions

Source: Taiwan Youth Climate Coalition (TWYCC)

Reference

1. Website of ICLEI Kaohsiung Capacity Center http://kcc.iclei.org/tw/
2. China Steel Corporation (CSC), 2016 CSC Corporate Social Responsibility Report, 2016
3. China Airlines, 2016 China Airlines Corporate Social Responsibility Report, 2016
4. Website of Delta Electronics Foundation http://www.delta-foundation.org.tw/
5. Website of Taiwan Youth Climate Coalition http://twycc.org.tw/
6. Environmental Protection Administration of Executive Yuan, Report of Participation in UNFCCC COP15 and CMP5, 2010
7. Environmental Protection Administration of Executive Yuan, Report of Participation in UNFCCC COP19 and CMP9, 2013
8. Environmental Protection Administration of Executive Yuan, Report of Participation in UNFCCC COP21 and CMP11, 2015
9. Environmental Protection Administration of Executive Yuan, Report of Participation in UNFCCC COP22 and CMP12, 2017
10. Environmental Protection Administration of Executive Yuan, Report of Participation in UNFCCC COP23 and CMP13, 2018
11. Environmental Protection Administration of Executive Yuan, International Environmental Partnership (IEP) https://www.epa.gov.tw/lp.asp?ctNode=35147&CtUnit=2802&BaseDSD=7&mp=epa
12. International Cooperation and Development Fund (ICDF), ICDF Annual Report of 2013-2017, 2017
13. Taipei City Government Department of Information and Tourism, Report of the CityNet Secondment Staff Programme 2017, 2017
14. Taiwan Institute for Sustainable Energy (TAISE), TAISE 10th Anniversary Special Issue, 2017

▲Kaohsiung Port

Chapter 9
Education, Training and Public Awareness

Chapter 9
Education, Training and Public Awareness

The legal basis for climate change education, training and public awareness in Taiwan has become more comprehensive. Environmental and greenhouse gas (GHG) related laws, including the Environmental Education Act and the Greenhouse Gas Reduction and Management Act, while all have climate change adaptation policy guidelines as a policy basis for adaptation. In the energy field, it is based on the action plan of the National Energy Conference. This chapter introduces climate change education, training and advocacy activities in Taiwan on campus, industry and incumbents, society and the public; as well as climate training activities promoted by civil society.

9.1 School Education

The United Nations Framework Convention on Climate Change (UNFCCC) recommends that States Parties report in their national communication the promotion or implementation of educational, training and public awareness policies, measures and plans in the field of climate change. It further urges States Parties to implement climate change concepts and climate actions in society and education, which has become one of the concepts and values of civil society.

The results of the UNFCCC Article 6 include the overall policy of education, training and public awareness in primary, secondary and higher education; public information circulation; training programs; resources or information centers and the participation of public and non-governmental organizations. The climate change education and training system covered by Taiwan's various stages of schooling includes campus climate change education, energy information lesson plans and textbooks, research and development, professional energy science and technology personnel training projects.

1. Climate Change Education on Campus

According to Adaptation Strategy to Climate Change in Taiwan, the Ministry of Education's plan for climate change adaptation education is a "single-minded" and "specialized" dual-spindle approach, with students as the main body, promoted by various academic systems, and generally formulated by law. It recognizes credits courses, promotes the cultivation of generalists by developing textbooks, curriculum aids and the 12-year national basic education syllabus. It further promotes the cultivation of generalists and the professionals integrated within the professional curriculum of colleges and universities, teaching alliances and industry-university links. These procedures actively enable to cultivate professionals in climate change.

The Ministry of Education promotes educational measures including the development of school textbooks, the nurture of teachers, the subsidy of colleges and universities to provide courses on climate change, the promotion of climate change education, the inclusion of learning courses and the promotion of climate change creative practice competitions, among others; which will promote cross-disciplinary teaching in the future. On the one hand, the Ministry of Education establishes the curriculum development plan in combination with the practice model of the climate change life laboratory and the problem-solving model in response to practical needs. On the other hand, the close inter-departmental cooperation opportunities boost the preparation of the required talents.

(1) Developing School Teaching Materials

The Ministry of Education compiles supplementary textbooks for the national, middle and high schools based on eight sectors including disasters, infrastructure, water resources, land use, coastal area, energy, agriculture and biodiversity or health among others. The array includes 8 sets of supplementary textbooks for students, 8 sets of teacher manuals; 2 batches of general education courses for planning climate change adaptation in colleges and universities, 7 collections of core teaching materials, 9 series of professional teaching materials on the development of disaster and life-sustaining infrastructure, 9 sets of professional courses in transportation, water resources, land use, coastal, energy, agriculture, biodiversity and health; and 1 set of supplementary textbooks and practical textbooks, with a total of 18 arrays of teaching materials.

(2) Teachers Cultivation

The Ministry of Education fosters cross-disciplinary professional workers in the long-term planning of climate change adaptation professional courses, establishes a teaching alliance cooperation mechanism and supports partner school teachers to promote the education of climate change adaptation to inherit experience, share resources and promote various fields. The development of professional courses on climate change has led to more than 200 college and university teachers becoming instructors in various fields of climate change. In addition to general education, there are teacher training camps for secondary schools, in the north, middle, south and east of the island, including 5 games that accounted with 461 participants and 13 workshops with 519 participants in the seminars. After the teachers had practical experience in the classroom, they were reviewed by the Ministry of Education and 101 teachers obtained a training certificate as seed teachers in climate change adaptation.

(3) Sponsoring colleges and universities courses related to climate change

To allow the students of colleges and universities to have the opportunity to understand and learn about climate change and related issues, the Ministry of Education has encouraged the promotion of climate change and adaptation talents since 2012. MOE has compiled 16 modules and professional courses for climate change adaptation in colleges and universities. The Ministry of Education has produced a total of 18 sets of teaching archives for the professional supplementary and practical textbooks for teachers to apply for the curriculum of the colleges and universities for sustainable development and climate change, general courses, credit courses or professional integration. In the 2016-2017 academic years, the Ministry of Education subsidized 360 general education courses and 414 classes with 25,000 students attending them. Between 2012 and 2015, nearly 40,000 students took some of the 24 related classes, such as climate and environment, sustainable environment, energy technology, agricultural production and biodiversity conservation and disaster prevention technology management. During 2016-2018 academic years, it subsidized approximately 134 professional integration course, with over 7,000 students.

(4) Promoting and advocating climate change education

Environmental education is one of the major topics in the 12-year National Basic Education Curriculum Outline. It has been integrated into the curriculum to promote environmental education. The five major themes of environmental education are

"environmental ethics", "sustainable development", "climate change", "disaster prevention" and "sustainable resources". Awareness and knowledge about different attitudes and skills in environmental actions and issues are the principal course objectives. Among them, themes such as "climate change" have different substantive connotations in all stages of education. In the national stage, it focuses on "awareness", including understanding and perceiving climate trends and extreme weather phenomena and recognizing that human behavior is the cause of climate change. The mid-national phase focuses on understanding the meaning of the "carbon cycle" to describe the critical point of global warming and the implications of climate change mitigation and adaptation, understanding Taiwan's adaptation policy in response to climate change and exploring international and national responses to climate change. The high school phase concentrates giving an understanding of the spirit of international conventions in response to climate change, to consider solutions tailored to local conditions, to cultivate basic education talents for climate change and adjustment and to enhance the nurture of talents for teachers and students to mitigate and adapt climate change.

(5) Involvement of the course and study

The Ministry of Education commissioned experts and scholars to develop environmental education topics for the 12-year national basic education and teaching examples in various fields to provide a reference for primary and secondary school teachers. The integration of teaching through different learning areas will help students to understand the phenomenon and causes of climate change, important policies or conventions at home and abroad and to develop awareness about maintaining environmental ecology by avoiding specific actions to aggravate climate change.

(6) Promoting climate change and adapt creative competition

To deepen students' understanding of climate change mitigation and adaptation, the Ministry of Education has stimulated students' creativity in climate change adaptation, and through their application, it has strengthened the ability to solve related problems. Because of it, teachers and students of colleges and universities have teamed up join and enter the final stages of different competitions, so they can study the workshop's drills, accompanying experts and scholars to strengthen their works to solve climate change related issues and enhance their climate change communication skills and mobility. Between the 2016-2017 academic year, college and university teachers and students team consolidated 41 groups. In the 2017-2018 academic year, they reached 38 teams. In the 2018-2019 academic year, it was increased to 150 teams.

2. Energy information lesson plans and textbook development

The Energy Bureau of the Ministry of Economic Affairs handles the "Coaching School to Promote Energy Education Program" and promotes energy education for primary and secondary schools nationwide. The promotion methods include the design and promotion of teaching materials, study sheets, special education texts, photography materials, and energy education centers, energy standard school, energy-saving campus series, energy knowledge contest, energy technology competition and national energy-saving activities, and among others.

The Bureau has completed 39 promotional materials for the 12-year National Education Energy Education Integration Teaching Plan, 28 energy reading study sheets, 17 special issues on low-carbon

life and green transportation education, 8 textbooks, and energy audio-visual materials since 2014. The Energy Education Achievements Exhibition and the Energy Education Teacher Training Activities of the Ministry of Education, and 25 energy education promotion centers are being nurtured each year to guide energy education activities and become a local energy education and information exchange platform and demonstration center. Each year, the Energy Education Standards School selects and awards the National Primary and Secondary School Gold Award (to 4 schools), the Silver Award (to 8 schools) and the Preferred Awards (to 8 schools) to encourage schools to jointly promote energy education. Furthermore, the Energy Education Information Network is established as an information platform for the promotion of energy education in primary and secondary schools nationwide, and to deepen energy education in the 12-year state education system.

Additionally, the Ministry of Education promotes energy science and technology talent development programs, and has established six energy technology teaching alliance centers, which includes the education in themes such as solar energy, biomass energy, wind energy, marine energy, industrial energy conservation, energy conservation and transportation energy conservation and energy storage (including electricity storage and heat storage). Each of the teaching alliance centers has 5 to 6 series of courses, and develops 80 arrays of energy science and technology courses and 12 meditators, with a total of 20,281 courses to be promoted on the development of cross-domain energy.

Furthermore, the Ministry of Education has also established an Energy Technology Education Teacher Training Center, under which two regional centers and primary and secondary schools are established to promote school projects. Regional centers and primary and secondary schools promote schools to form regional alliances for energy science and technological education. The project promotes geophysical energy science and technology education, combines the primary and secondary schools to promote the teachers and teaching resources of the school, encourages primary and secondary schools to promote professional consultation of schools, operates regional primary and secondary energy education communities and assists in the implementation and promotion of the project to achieve the goal of fully implementing energy science and technology education in primary and secondary schools.

The executive team consists of 26 colleges and 19 primary and secondary schools to participate in the promotion of energy technology education. Through energy-based courses, cross-disciplinary teachers, teachers from the industrial sector and internships in the industry, the domestic energy sector is expected to retain national potential talents in the energy sector, to train energy seed teachers and to develop education modules to implement energy knowledge in primary and secondary school teaching activities through sharing, teaching observation and promotional actions, which reduce the pressure on teachers to prepare lessons and find teaching resources, and thus enhances the substantive effects of implementing energy education. From 2014 to 2017, a total of 995 seed teachers of energy science and technology were trained in primary and secondary schools.

3. Professional energy science and technology talent cultivation

The Ministry of Science and Technology implements the second phase of the national energy science and technology plan. Started in 2014, it is expected to be completed at the end of 2018. In addition to promoting various research and

development programs based on energy and clean energy technologies, the Energy Technology Strategy and Energy Policy will be established. Linkages such as bridging and communication, energy technology transfer and international cooperation are linked to various technologies, and the mission of nurturing professional energy science and technology talents are promoted at the same time as the plan. The project was implemented until January 2017, with 1,151 papers published at domestic and foreign seminars, 331 domestic and foreign important journals, 192 domestic and foreign general journals, a total of 1,674 papers, and 1,016 masters and PhDs. The total number of participants included 1,313 senior professional energy science and technology talents.

9.2 Job Training

To enhance Taiwan's energy autonomy and strengthen energy security, the government began to accelerate the promotion of the green energy industry in May 2016 and is committed to fully develop green smart grids and set renewable energy power generation targets. The development of the domestic green energy industry, talent introduction and technology must be carried out simultaneously in addition to promoting R&D, the production of hardware and software technology for active international investment. Through the training and capacity building of industry and incumbents, it will be promoted to the ground. The development of the green energy industry encourages energy service industry to foster new ventures.

1. Industry incumbent training

(1) Energy Management Professional Training

To promote energy management and auditing systems for energy users and enterprises, the Energy Bureau of the Ministry of Economic Affairs conducts annual training courses for energy management personnel, designs professional courses in areas such as energy check, energy saving plan, power management and thermal management where users can obtain certificates for the training. The number of managers certified has reached approximately 9,000, which can assist about 4,700 energy users to conduct energy management actions. Additionally, the retraining of officers who have obtained the certificate for more than 3 years will be carried out. Through advanced courses, the professional ability of the manager can be improved, and approximately 800 people will be trained each year.

(2) Energy industry GHG reduction management professional training

Since 2005, the Energy Bureau of the Ministry of Economic Affairs has assisted the energy industry in conducting GHG emissions inventory, its verification and registration operations and the introduction of ISO 14064 international GHG management standards to assist the energy industry to gradually and systematically establishing GHG emission management to reduce GHG emissions. Since 2018, it has focused on assisting the energy industry that is expected to be managed by the Greenhouse Gas Reduction and Management Act and to integrate the knowledge needed for GHG reduction management to strengthen the capacity building of the energy industry response to the changes and dynamics in the domestic temperature management system. To achieve these goals, it is necessary to integrate the knowledge in the energy industry, involving the development trend of the international reduction strategy, the relevant sub-laws of the Temperature Management Act, the promotion of the current situation, reward mechanisms, the operationalization of carbon emissions trading, the introduction of the

practice, the application of tools and carbon reduction technology and to introduce the energy industry into GHG reduction management. The Bureau will build the “Learning map for the energy industry to trend talents of GHG reductions management” that will allow the development of energy industry personnel through the training on GHG related sub-laws or management system development to respond to the industry demands. It will further continue to educate professional personnel for the energy industry GHG reduction management, to enhance the energy industry reduction management awareness, skills and mobility and establish an official window dialogue for long-term information, and give back to the energy industry to reduce the amount and talent management response strategy research.

(3) Industrial energy saving and carbon reduction personnel training

The Industrial Bureau of the Ministry of Economic Affairs set up a manufacturing energy-saving and carbon-reducing service group in 2008, which began to conduct energy-saving and carbon-reducing personnel training for the manufacturing industry. Over the years, the course content has been refined with domestic and international GHG management trends and industrial needs, GHG reduction and management methods, industrial GHG reduction practices, GHG exchange project examples, smart energy monitoring and other practical courses.

The SMEs and the Processing Export Zones Management Office of the Ministry of Economic Affairs handle energy-saving management-related training courses to help manufacturers find the potential for energy conservation and carbon reduction and to implement energy-saving and carbon-reduction improvements in order to enhance manufacturers' energy-saving awareness and technology. The Science Park Management Office of the Ministry of Science and Technology promoted the competitiveness of the park's employees and stimulated and enhanced the overall innovative management thinking, research and development energy of the Science and Technology Park. It also provides training courses or seminars in application areas such as “smart identification”, "green energy technology", "display and touch technology" or "optical design.

2. Environmental education personnel certification and training

The Environmental Protection Agency of the Executive Yuan promoted the National Environmental Education Action Plan. By the end of 2016, the number of certified environmental education personnel was 11,112 (including 5,709 certified by the Ministry of Education) and 28 environmental education institutions were engaged in environmental education planning, promotion or personnel training and other matters, such as to provide citizens with a more comprehensive environment for educational learning. In 2016, the Environmental Education Business Administration completed the "Environmental Education Institutions and Environmental Education Facilities Assessment Operation Site Manual" and organized an expert assessment team to conduct the evaluation of five institutions and 25 facilities.

To enhance the professional knowledge of the environmental educational staff, the EPD has also launched the "30-hour study on core subjects for environmental education staff", "Visionary Standard Learning Workshop for Environmental Education Facilities" and "Advanced Practice Training Course for Environmental Education Staff". These construction activities are expected to deepen the quality and connotation of environmental education personnel.

9.3 Public Awareness

1. Low Carbon and Sustainable Homeland

To comply with the trend of the world, Taiwan has repeatedly discussed the issue of low-carbon sustainable homes. Domestically, the "Permanent Energy Policy Program", the "National Space Development Strategy Planning National Conference " and the "98 National Energy Conference", all listed low-carbon sustainable homes as a policy vision, showing Taiwan's emphasis on promoting low-carbon sustainable homes. The structure of promoting low-carbon sustainable homes abroad to plan the relevant operating mechanism of low-carbon sustainable homes in Taiwan is shown in Figure 9.3.1.

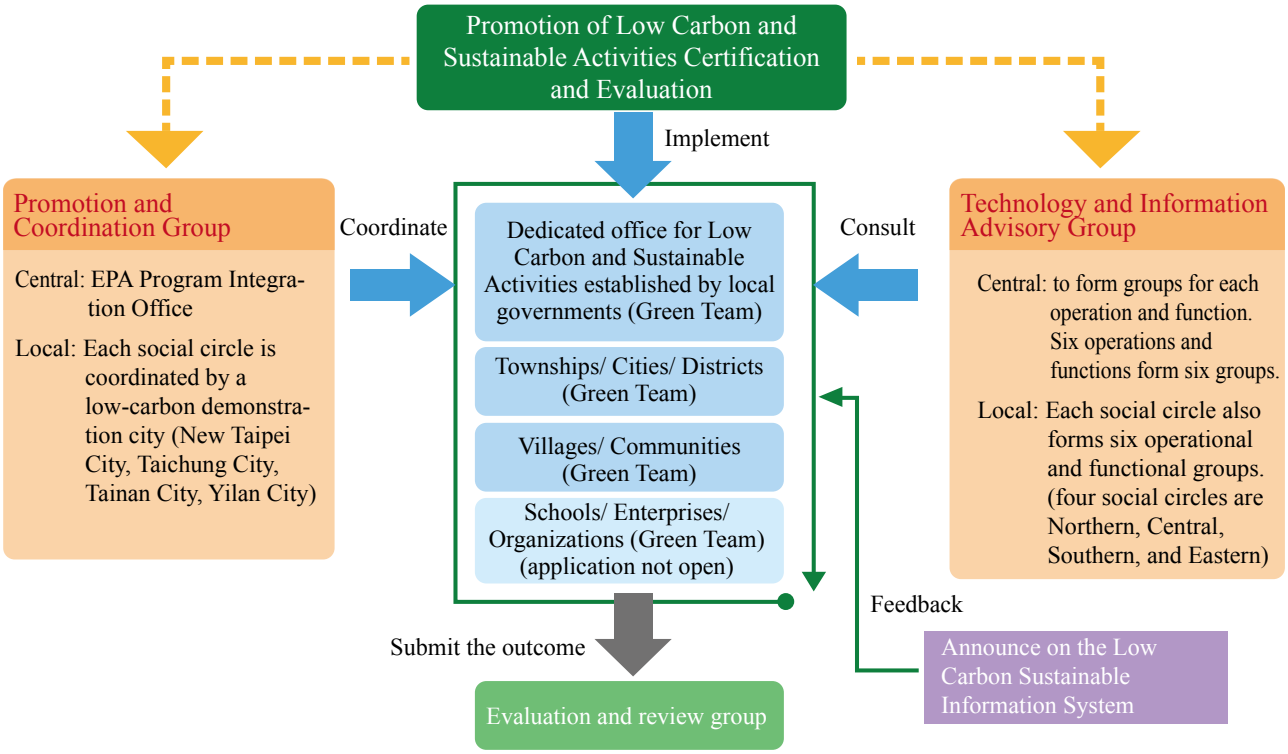


Figure 9.3.1 Framework and Mechanism of Low Carbon and Sustainable Homeland

Sourece: Executive Yuan Environmental Protection Administration

Since 2010, the EPA has promoted low-carbon sustainable homes integrating the strengths and resources of central and local governments and private enterprises and has built deep-rooted low-carbon sustainable communities to promote ecological greening, green energy conservation, green transportation and resource recycling. Six major functions such as carbon life and sustainable operation, and low-carbon sustainable measures, have continued to spread successful experiences to neighboring villages, driving neighboring communities to jointly promote the concept and practice of energy conservation and carbon reduction, from daily food, clothing, housing, education and music with specific actions in the line of to reduce carbon in everyday life activities.

To plan and promote the construction of low-carbon sustainable homes, the EPD proposes the connotations and principles of six low-carbon sustainable homes, including “sustainability for sustainable development”, “efficient clean energy management”, “establishing urban green axis”, "cultivating low-carbon living habits", "participation of community and community groups" and "thinking about climate change". It further proposes six functional low-carbon sustainability measures to achieve in the construction process to reach the established goal and promotes specific and executable action items.

In the implementation in the construction sector, the EPD has gradually expanded from small-scale community demonstrations to cities. Through cooperation with local governments, village communities demonstrations have been selected to continue to assist in the energy-saving diagnosis and implementation of low-carbon improvement measures in order to further expand the implementation scope to decrease the carbon development of the city and implement the highlight plan demonstration.

Low-carbon sustainable homes establish a “certification and evaluation system”. While the participating units at the county level are mandatory, for participating units in townships or villages, the principle of spontaneous and non-enforcement is adopted. Before the registration, the participating units must set up a green team, write a low-carbon sustainability declaration and a description of the regional status, and submit the above three documents together with the online registration before completing the registration. After confirming the eligibility, you can select the action items you want to implement in the background of the Low Carbon Sustainable Home Information Network, and you will have the opportunity to obtain relevant education training and counseling information to assist the participating organizations to continue the implementation of their selected low carbon action project for home. After the follow-up execution has demonstrated a certain effect, a document with relevant outcomes will be uploaded and the evaluation application will be submitted.

Currently, the rating of the plan is divided into three levels, namely, finalist, bronze and silver. The follow-up will be based on the implementation status, adding gold, platinum or diamond labels. The participation process for certification rating is shown in Figure 9.3.2. The EPD will also place detailed information on the implementation of the content information on the "Low Carbon Sustainable Home Certification Award Promotion Project" and related briefings in the download section of relevant information in the Low Carbon Homepage for people to view and download.

To enhance the awareness of climate change adaptation and develop environmental education, the EPD has launched “Low-carbon Sustainable Community Seed Training”, which is specifically targeted at local government environmental protection bureaus, low-carbon project offices, and village chiefs who promote low-carbon sustainable community-related businesses. Village officers, community development associations, management committees, volunteers and interested people, according to different types of demonstration communities in North, Central, South and East of Taiwan, conduct theme-based training exercises on environmental issues close to the living environment and lifestyle in the course "Low Carbon Sustainable Community Seed Training Seminar".

In the training workshop, the trainees serve as seed personnel to pass and share relevant experience to the community and actively develop a low-carbon sustainable social environment. The course covers areas such as mitigation adjustment, community resource inventory, green map design, community image recording, green space creation, energy-saving technology; to transfer and share relevant knowledge to other people, to lead the community to promote low-carbon sustainable work and environment coexistence and create a vision of a low-carbon sustainable home.

2. Community University Education Promotes Community Based Adaptation, CBA)

The climate change adaptation system is an emerging concept. It is not enough to take the lead in the public-sector promotion but necessary to rely on the people to jointly raise the awareness of climate change crisis, adaptability and knowledge. The National Development Council, the Environmental Protection Agency, the Ministry of Education and other relevant ministries and commissions will conduct adjustment and promotion in different forms to strengthen climate change and adjust public participation and communication skills.

Since 2012, the Environmental Protection Agency has commissioned the National Association of Community Universities to promote the “National Community University Climate Change Adaptation Education Promotion Project”. The association works with community colleges around the world to promote community-based climate change adaptation (CBA) as a long-term vision, to build relevant platforms, to promote the “4 hours climate change adaptation activities” and the “32-hour climate change adjustment courses” training and educational programs and the CBA program implementation method flow and mechanism, as shown in Figure 9.3.3.

The National Association of Community Universities collaborates with community colleges in different urban and rural areas to build a local community climate adaptation learning center. In terms of strategy, the National Association for the Promotion of Community Universities is used as a platform for the development and communication of community climate adaptation plans. Currently, the CBA Centers for the five climates of community development are more mature, each adapting to local conditions and developing different goals. The CBA Program Executive School of the University of Science and Technology and its themes, as listed in Table 9.3.1.

Figure 9.3.2 Application Process of Low Carbon and Sustainable Homeland Certification and Evaluation

Sourece: Executive Yuan Environmental Protection Administration

Table 9.3.1 Community Universities CBA action plans implementing schools and themes

	School	Themes
Endurance CBA program	Yonghe Community College, New Taipei City	Climate change in local citizen action
	Wenshan Community College, Taichung City	Visiting the Footprint of Yuyong River- Construction of the Cultural Life Circle of Dadu Mountain
	Zengwen Community College, Tainan City	Zeng Wen climate change hydrology school circle- created by fish and vegetables symbiosis, shared with water
Trial CBA program	Wenshan Community College, Taipei City	Shang Shui Wenshan: Rainstorm Disaster Reduction and Adjustment Project
	Yilan Community College	Climate change adaptation of new farming community

Source: Juridical Association Community University, National Promotion Association Climate Change Adjustment Education Promotion Project Work Plan Final Report, 2015

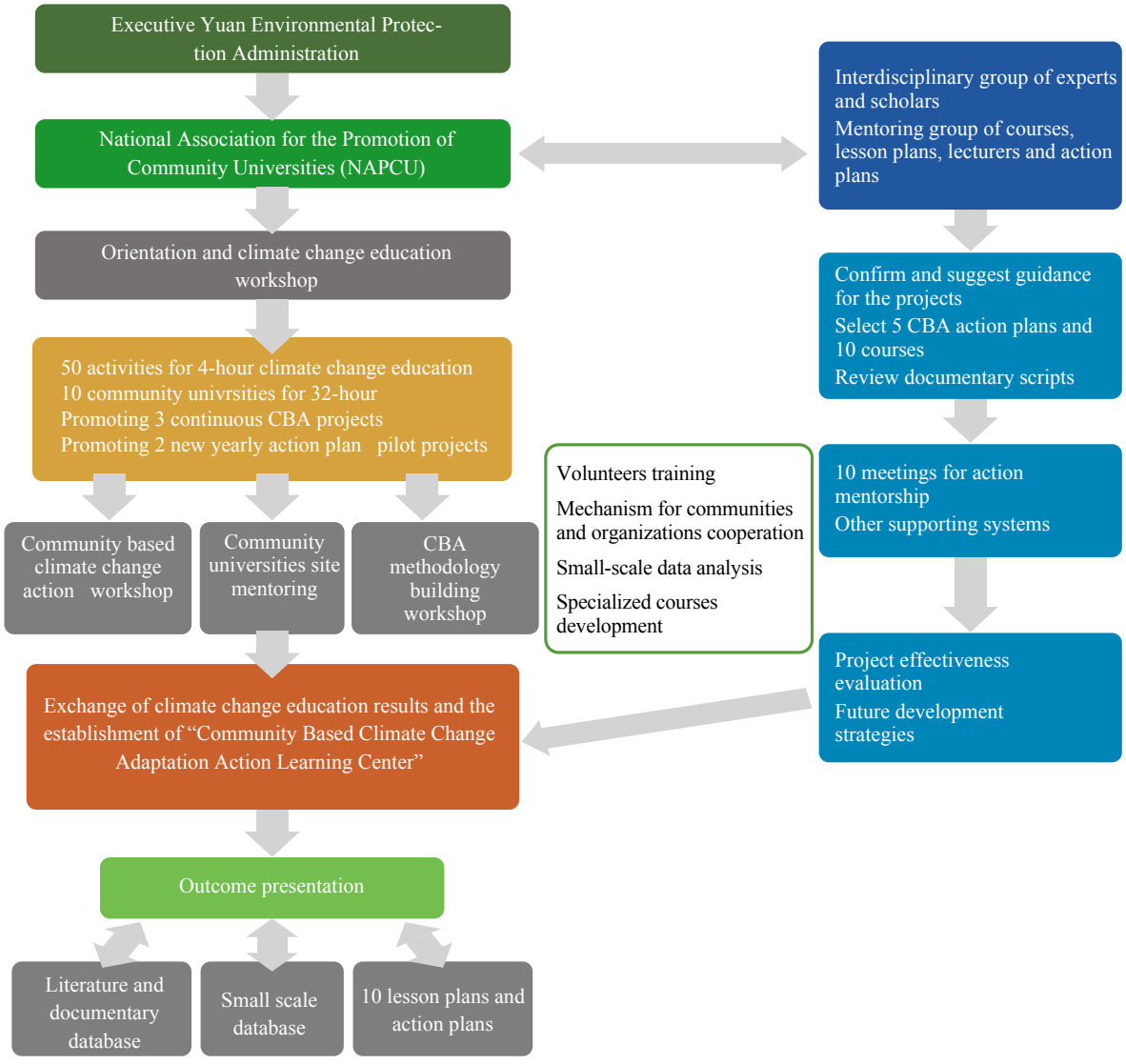


Figure 9.3.3 Process and Mechnisms of Juridical Association Community University's CBA Program

Source: Juridical Association Community University, Final Report of Climate Change Adaptation Education Promotion Project, 2015

Various community universities have developed different strategies according to local conditions. For example, Tainan City's Zengwen Community University has created many wetland environment strategies because it is often flooded with water due to the downturn in the sea. At this stage, it is important to introduce water through the on-site practice courses such as fish and vegetable symbiosis, which can make residents recall the memory of filled farm ponds in the past, so as to raise the awareness of adaptation. The Yilan Community University has focused on the clarification and adjustment of climate change issues, such as the introduction of agricultural reform fields and agricultural experts, to discuss whether climate change has any impact and whether it can withstand scientific testing. The development of the socially-experienced Yonghe Community College in New Taipei City complemented the development of the early ecological double-sum system project. After participating in the PCVA workshop held by Oxfam, Yonghe University successfully piloted it in Yonghe Yongji the PCVA program. These examples are only a few examples of community climate adaptation in Taiwan.

3. Promoting the establishment of a climate change adaptation information platform

The Internet is one of the fastest media transmitters of contemporary information. To effectively promote awareness to the whole population, the National Development Association readjusts the scientific knowledge of climate change and public information to information easy to read and to understand by the general public as a climate change adaptation measure. At the same time, in May 2013, the information platform for climate change adaptation website was created to build the Ark-Climate Change and Adaptation Portal. It provides relevant government information on climate change adaptation, domestic and international adjustment news, popular science knowledge, expert columns, adjustment cases and related links to make information public and available. The Portal is expected to become an established platform for communication and environmental education where conduct dialogue and information exchanges.

Since the implementation of the "Warm Management Law", the EPD completed the "Climate Change Information Integration Network" in 2017, which provides basic knowledge of climate change related to local government and public responses, as well as news from the perspective of the international climate change adaptation and mitigation actions, conference and events information. The results of Taiwan's promotion show the successful provision of educational awareness tools and reference information network to promote climate change.

The Building Research Institute of the Ministry of the Interior has also built a webpage of smart green buildings. The website introduces the stamps, regulations, interactive multimedia introductions and audio-visuals of smart green buildings, green buildings and green building materials. Additionally, the intelligent living space display center is also established in Taipei to guide the development of innovative products in space and technology integration, through the intelligent application of the living environment display center, smart residential unit display areas and smart homes in the South-Central Exhibition Center combining RFID technology in the construction with innovative integration application demonstration. The easy-to-construct housing of industrial application results provides a safe, healthy, convenient, comfortable and energy-saving living environment created by the Chinese people to understand and experience the building combined with intelligent technology application, and

implements the policy of promoting intelligent living space.

The Transportation Research Institute of the Ministry of Communications has established a green transportation website to provide the general public and primary and secondary school students with relevant knowledge about green transportation systems, new technical knowledge, legal interpretation, professional technology, research results, statistics and other related information. It has also set up communication channels for discussion forums, and provides online teaching, file downloading and Q&A services, to achieve educational promotion, quick access to relevant materials and exchange of related topics to promote the public's consensus on green transportation systems, and to facilitate future green transportation with the promotion of related projects.

4. Organize creative climate change adaptation and related promotion activities

To promote the concept of adaptation to the whole population, the National Development Council, the Environmental Protection Agency and relevant authorities have actively organized various climate change adaptation creative promotion activities. The nature of the activity is from a more active, life-oriented and interactive multi-creative promotion campaign to a more in-depth and professional climate change risk communication, allowing the public to understand the importance of climate change adaptation from shallow to deep, including the organization of multiple ideas such as adaptation campaigns, climate change adaptation and risk communication activities.

Some promotional activities organized by the EPD are to promote carbon neutrality, conduct environmentally friendly low carbon activities and markings; local low carbon life performance appraisal; low carbon life declaration and self-evaluation. Other projects carried by national institutions and schools include to promote weekly fruits and vegetables day activities, green procurement and consumption, energy conservation, water conservation, power saving publicity and manual production, the establishment of relevant event websites and a full interaction with the public, in environmental low-carbon activity platform, such as Eco Life, clean home, Green Life Net and so on.

Additionally, to strengthen the communication between the civil society and the government ministry on climate change issues, the majority of the society adheres to the core spirit of “partnership, dialogue, mutual participation, and common face”. The EPA started in 2011 to organize civil cafe activities, handle national public conferences, and organize 855 suggestions from the district civic conference. In May 2012, it held the “National Climate Change Conference” citizen café, on the theme of “Taiwan 20XX: Facing Climate Change, Preparations that Taiwan has to do”. It was an open, participatory discussion on 855 suggestions that was attended by more than 500 representatives of civil society and government-related ministries.

The Energy Bureau of the Ministry of Economic Affairs provides different energy-saving techniques, energy conservation manuals, incentive measures, praises and competitions, among others; to promote and raise public awareness of energy conservation, according to different objects such as energy saving, energy saving in residence, industrial energy conservation, energy saving in schools, and power saving in counties and cities. The Bureau also has organized exhibitions, held meetings, built the

website to promote the different actions and hold civic activities to reward energy conservation.

To promote the national response to power-saving actions, the energy-saving incentive fund was implemented from August 2014 to the end of 2016. The calculation method uses the comparison of the current electricity consumption of the user with that of the same period last year. For every watt of power saving, the user gets 0.6 NTD as a reward. Additionally, by October 2018, the Energy Bureau has certified 51 kinds of products and promoted energy-saving labels. A total of 305 brands and 6,658 energy-saving labels products are available for purchase. Over the years, we have handled the "Energy Conservation Standard Award" competition, the “Energy Conservation Excellence Awards” and recognition activities for industrial, residential, construction, and government schools. We have provided energy-saving standards and models for reference by all dimension to recognize energy conservation.

5. Promote the national climate change adjustment education plan

The Climate Change Adaptation Education Department is an important cornerstone of the country's future climate change. Considering the characteristics of climate change and adapting to cross-disciplinary and inter-departmental characteristics, the adjustment of education needs to be promoted from the principles of integration, comprehensiveness and effectiveness and needs to be targeted at different objects. The field is properly planned and promotes the participation of all citizens. In 2012, the National Development Council developed the "Climate Change Adaptation Education Program for All", and promoted cooperation with the Ministry of Education, schools, and educational institutions through the integration mechanism of the project. Under the core concept of promoting climate change adaptation, we will incorporate innovative creative ideas and consider the whole population as the target of education. Different learning objectives and practices are proposed to adapt climate change to roots through education, and therefore, we divide them into central government officials, local government officials, teachers and students of all levels of schools, members of non-governmental organizations and the general public.

To make it easier for people to understand the concept of climate change adaptation, the National Development and Development Association and the Environmental Protection Agency will present in a concise and easy-to-understand manner, compiling various climate change adaptation education papers, such as the Environmental Protection Agency's "Climate Change Adaptation Education Manual" to strengthen the central and local knowledge. The training of public servants is mainly based on the case of climate change and the case of adaptation. The "Encyclopedia of Climate Change" is aimed at the public to guide the whole population to gradually demodulate and implement it in life. To give the whole population a deeper understanding of climate shock, we will film the "Climate Change and Sustainable Taiwan", which will deepen the concept of universal adjustment.

In 2012, the Department of Health (the predecessor of the Ministry of Health and Welfare) produced the "Climate Change and Chronic Disease Prevention and Control Manual" as a reference for popular health education. The Ministry of Health and Welfare continued to do a good job in the high-temperature and low-temperature early warning action plan based on meteorological forecasts, publicizing the media, reminding the public to pay attention to extreme weather, preventing heat damage, monitoring

hospitals to provide emergency medical treatment for heat damage and combining folk resources and localities. Health care and social welfare units set up emergency resettlement shelters at low temperatures, and strengthened visit and care services for vulnerable people such as elderly people living alone and street residents.

9.4 Civil Society Organizations Empowerment

By the end of 2017, Taiwan's non-governmental environmental protection groups and organizations had 58 environmental protection consortiums approved by the Environmental Protection Agency of the Executive Yuan and 296 national environmental protection groups. As the issue of global warming being widely immersed in the public, most of Taiwan's non-governmental environmental groups adhere to international issues, implement local practices and continue to participate in and care about the development of international climate issues, such as the negotiation and signature of the Paris Agreement, which was highly promoted in Taiwan. The promotion methods include online blogs, electronic newspapers, publications, recruitment and promotion of voluntary services, courses, painting competitions, exhibitions and forums. In addition to interpreting important international scientific information, it also provides climate response and solutions or practices for change. This section summarizes the important advocacy activities of civil society groups in Taiwan to promote climate culture.

The Delta Electronic Culture and Education Foundation promotes climate change, energy and other domestic and international information through the establishment of a low-carbon blog website and Facebook page, and recruits energy education volunteers to handle energy education courses or energy media salons. The “Taiwan Green Building Big Exhibition” is a key project promoted in recent years. In addition to exhibiting the green buildings built by Delta Electronics in Taiwan, it also shares the energy-saving technologies needed for construction, forming a green building, low-carbon transportation and life. Power is widely recognized by all walks of life. The exhibition pictures are shown in Figures 9.4.1 and 9.4.2.

Figure 9.4.1 Delta Electronics Foundation held “Green Footprint- Delta Green Building Exibition” in 2016

Source: Delta Electronics Foundation

Figure 9.4.2 Delta Electronics Foundation held “Ecological Transportation Festival- Green Footprint- Delta Green Building Exibition” in 2017

Source: Delta Electronics Foundation

The Environmental Quality Protection Foundation (EQPF) focuses on climate change adaptation and environmental education, handles activities such as the world's children's environmental writers competition, "climate change and children" itinerant education project, forums on ecology and environment, environment and the rule of law, and establishes a dialogue platform for environmental education in Taiwan. (http://www.TEED.org.tw) The 27th forum event, which had nearly 250 movies and more than 10 environmental broadcast series.

The Taiwan Sustainable Energy Research Foundation (TAISE) continues to promote awareness of sustainable energy-related issues, establish exchanges with academic and technical professionals related to sustainable energy at home and abroad and promotes sustainable energy-related publications and professional books. In recent years, it has been more active in strengthening the domestic industry's concerns about sustainable energy-related issues. In addition to the establishment of the “Taiwan Enterprise Sustainability Research and Training Center”, it promotes training courses and activities, and urges companies to fulfill their corporate social responsibilities and achieve sustainable development objectives, encourages companies to enhance the quality of their sustainability issues and the amount of governance information and to strengthen their investment and emphasis on maintaining a friendly sustainable development of the environment under a charitable society and continues to hold the "Taiwan Enterprise Sustainability Award" selection campaign. The number of companies that registered for the past year reached 209.

In response to the UN's 17 Sustainable Development Goals (SDGs), the Sustainable Energy Foundation has established and summarized the core objectives, the specific goals and the corresponding indicators of the "Taiwan Sustainable Development Goals" after many sustainable meetings and forums. On this basis, in the year of 2018, we cooperated with the Taiwan Enterprise Sustainability Research and Training Center to jointly establish the“Alliance for Sustainable Development Goals”(A·SDGs), and the photo of the inaugural meeting is shown in Figure 9.4.3.

Figure 9.4.3 TAISE launched Alliance for Sustainable Development Goals (A・SDGs) with industry, government, research institute and NGOs

Source: Taiwan Institute of Sustainable Energy (TAISE)

Figure 9.4.4 Taiwan Youth Climate Coalition (TWYCC) held “People’s Climate March” and “Taipei Biking March”

Source: Delta Electronics Foundation

Taiwan Youth Climate Coalition (TWYCC) gathers a group of young people from all over Taiwan, who show concern for the environmental protection and climate change. It is the first youth-oriented environmental NGO in Taiwan, which focuses on talent training, independent action and cultural heritage. It is looking forward to establishing a youth exchange platform for Taiwan's environmental and climate issues and continuing to promote youth participation in local and international climate action. Long-term youth workshops, school tour speeches, and sharing sessions will be held to connect young people with young people. Together with international youths, they will promote climate change transformation actions, as shown in Figure 9.4.4. Since 2012, it has regularly participated in the UN climate change conferences and held side events with international youths to continue to pay attention to international climate change issues. From 2018 to 2020, it will promote the bottom-up, individual-to-state with the "Taiwan Youth Climate Inventory" program. The climate action initiative, the picture of the camp is shown in Figure 9.4.5.

Figure 9.4.5 Taiwan Youth Climate Coalition (TWYCC) held “2018 Taiwan Youth Climate Stocktake Camp”

Source: Taiwan Youth Climate Coalition (TWYCC)

Reference

1. Ministry of Education, Twelve-year National Basic Education Curriculum Outline" National Primary and Secondary Schools and Ordinary Senior Secondary Schools in the Field of Natural Science, 2018
2. Website of Delta Electronics Foundation http://www.delta-foundation.org.tw/
3. Website of Taiwan Institute of Sustainable Energy https://taise.org.tw/
4. Website of Center for Corporate Sustainability http://www.ccstw.net/
5. Website of Taiwan Youth Climate Coalition http://twycc.org.tw/
6. Executive Yuan Environmental Protection Administration, Report of 2016 National Environmental Education Action Plan, 2016
7. Executive Yuan Environmental Protection Administration, website of Low Carbon and Sustainable Homeland https://lcss.epa.gov.tw/_x/_lcss/lcssgrade/viewgrade-1.aspx
8. Executive Yuan Environmental Protection Administration, Final Report of Low Carbon and Sustainable Homeland construction and implementation evaluation project, 2012
9. Executive Yuan Environmental Protection Administration, Low Carbon Community Construction Manual, 2013
10. Executive Yuan Environmental Protection Administration, National Action Plan for Climate Change, 2017
11. Executive Yuan Environmental Protection Administration, National Environmental Education Action Plan (2012-2015), 2014
12. Executive Yuan Environmental Protection Administration, National Environmental Education Action Plan (2016-2019), 2016
13. Executive Yuan Environmental Protection Administration, Special Issue of National Climate Change Summit, 2012
14. Ministry of Economic Affairs Energy Bureau, Report of Counseling schools promote energy education program, 2017
15. National Development Couincil, Adaptation Strategy in Taiwan, 2012
16. Ministry of Education, Final Report of Disaster prevention and climate change adaptation education program, 2017
17. Ministry of Education, Final Report of Climate Change Adptation Education Alliance Programe, 2017
18. Ministry of Education, Final Report of Climate change creative implementation competition plan, 2017
19. Ministry of Education, Final Report of Energy Technology Talent Cultivation Program, 2017

20. Ministry of Economic Affairs, Energy users set up or entrust technicians or qualified energy managers to set up registration methods, 2010

21. Ministry of Economic Affairs, Fourth National Energy Conference specific action plan, 2015

22. Website of Environmental Quality Protection Foundation (EQPF) http://www.eqpf.org/home.aspx

23. Juridical Association Community University, Final Report of Climate Change Adaptation Education Promotion Project, 2015

24. Executive Yuan Environmental Protection Administration, website of enviromental protection projects reports: http://epq.epa.gov.tw/project/FileDownload.aspx?proj_id=1040300317

2018

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)