UNFCCC National Communication of the Republic of China (Taiwan)

Environmental Protection Administration, ROC (Taiwan)
July, 2002

Table of Contents

List of Tables

List of Figures

EXECUTIVE SUMMARY

Forward

In order to protect the global environment and to avoid adverse impacts from international politics and trade, the Republic of China (Taiwan), though not a member of the United Nations, has always complied with international environmental treaties and acted as a responsible member of the global village. In May 1992, the Executive Yuan established the ministerial-level inter-departmental agency Global Change Working Group to coordinate activities related to United Nations Framework Convention on Climate Change (UNFCCC) and other global environmental issues. In August of 1994, the working group was further reorganized and elevated as Committee on Global Change Policy (CGCP), under which the UNFCCC Working Group was established. Due to the growing importance of sustainable development to countries around the world, the government decided to integrate all domestic matters related to sustainable development. In August 1997, CGCP was expanded to form the National Council for Sustainable Development (hereinafter referred to as the "Council"), while the Atmospheric Protection and Energy Working Group under the Council was responsible for affairs related to the Montreal Protocol and the UNFCCC. In 1999, the Council was further elevated and chaired by the Vice Premier, thus showing our commitment in response to the UNFCCC.

The emissions of greenhouse gases (GHGs) are closely related to the use of energy. Since Taiwan produces very little energy on its own, most of the energy resources for domestic use are imported. In 1998, about 80% of Taiwan’s energy supply relied on imported coal and petroleum. Under the present industrial energy structure, maintaining the competitiveness of Taiwan's industries while reducing carbon dioxide emissions has become one the major challenges for our efforts in reducing GHG emissions.

The annual carbon dioxide emissions per capita in Taiwan are estimated to have been increasing at a rate of 7.5%. The per capita emission was 5.57 tons in 1990, 7.59 tons in 1995, and 9.83 tons in 2000, showing that Taiwan's economy is still fast developing. If Taiwan were to reduce its GHG emissions to 1990 level by the year 2010 as Annex I countries, we would have to reduce our projected 2010 GHG emissions by 227%. Emission reduction of this magnitude would certainly create tremendous impact on Taiwan's economy and would also go against the principle of fairness under the UNFCCC.

Taiwan is an island with a high population density. Since 74% of the island's surface is mountainous, the majority of the population and industrial activities are concentrated in the remaining 26% flatland. Such condition has created one of the world's highest environmental

loading, rendering our GHG reduction efforts more difficult.

Nevertheless, in response to the Kyoto Protocol adopted in December 1997, and searching for a harmonized policy among economic development, energy stability and environmental protection, Taiwan convened the National Energy Conference in May 1998. The objectives were to discuss the developments in the UNFCCC and our response strategies, energy policy and energy mix restructuring, industrial policy and restructuring, energy efficiency improvement and energy technology development, and energy policy tools. Consensus on our position in the UNFCCC and strategies for emissions reduction were also reached.

Chapter 1 Background

Taiwan is located off the Southeastern rim of Asia, facing the Pacific Ocean in the east and the Taiwan Strait in the west. The island of Taiwan extends from 119 E to 124 E in longitude and 21 N to 25 N in latitude, and its total area is about 36,006 km^2. Taiwan is 377 km long north to south and 142 km east to west at its widest point. Its coastal length is about 1,140 km. The land over 100 m above sea level makes up about two-third of the total area, and arable land makes up about one-fourth. The average annual temperature is about 22-25℃, about 27-29℃ in the summer and about 15-20℃ in the winter. The average annual rainfall in lowland is about 1,500-2,500 mm, reaching above 4,000 mm in mountainous regions. Of the 36,006 km^2 of land in Taiwan, forest area consists of about 58% of the total, followed by about 25% of arable land. By the end of 1998, the population of Taiwan totaled 21.93 million and increased to 22.28 million in 2000, and 23.92 million by 2010. The national circumstances of Taiwan are shown in Table 1.

Since the Second World War, economic development in Taiwan went through four periods: agriculture, light industry, heavy industry, and technological industry. This transition created an economic miracle in Taiwan; our economic growth rate ranged from 5.39-13.59% between 1966 and 2000, with the exception of below 5% in 1974, 1975, 1982, 1985, and 1998. In recent years, our industrial development has slowed, while our service industry is expanding year after year, reaching 65.6% of GDP by 2000. This shows that Taiwan's industrial structure is gradually transforming toward that of a developed country.

Table 1. Taiwan's National Circumstances

Statistics	2000
Population	22,276,672
Area (km^2)	36,006
GDP (US$100 million)	3,026
GDP Per Capita (1998 US$)	3,027
Percentage of Informal Sectors in GDP	NE
Percentage of Industries in GDP	32.4
Percentage of Service Sector in GDP	65.6
Percentage of Agriculture in GDP	2.1
Agricultural Land Area (km^2)	8,515
Urban Population (%)	NE
Livestock (1000, number slaughtered)	Cattle: 25; Swine: 9990; Lamb: 202 Chicken: 389,770; Duck: 34,099; Goose: 6,503
Forest Area (km^2)	Coniferous: 4,393; Broadleaf: 11,174 Bamboo: 1,495; Mixed 3,954 Total: 21,017
Poverty	NE
Life Expectancy (year)	Male: 72.6 Female: 78.2
Literacy	Above six-years of age: 95.7%

Note: 1998 GDP calculated with exchange rate of NT$32 = US$1
NE: Not Estimated

In 2000, energy supply in Taiwan totaled 106.23 million kiloliters of oil equivalent (KLOE), of which 51.4% was composed of petroleum, 30.8% coal, 9.0% nuclear power, 6.7% natural gas, and 2.1% hydroelectric power. Imported energy made up over 96% of total energy supply. Energy consumption totaled 90.91 million KLOE, of which the industrial sector consumed the most with 48.5%, transportation 17.0%, residential 12.5%, commercial 5.7%, and agriculture 1.5%. The compositions of Taiwan's energy supply and consumption are shown in Figures 1 and 2.

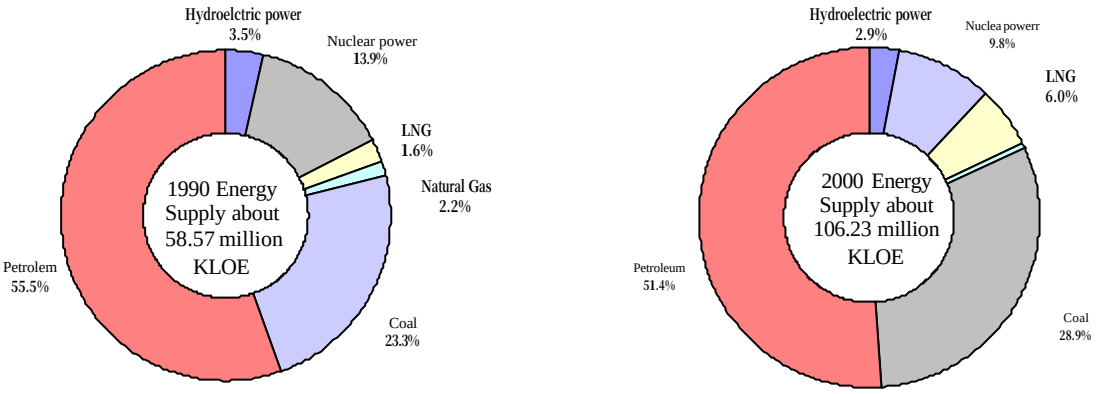


Figure 1. Taiwan's Energy Supply Composition in 1990 & 2000
Source: Energy Commission, MOEA, Taiwan Energy Statistics Annual Report (2001)

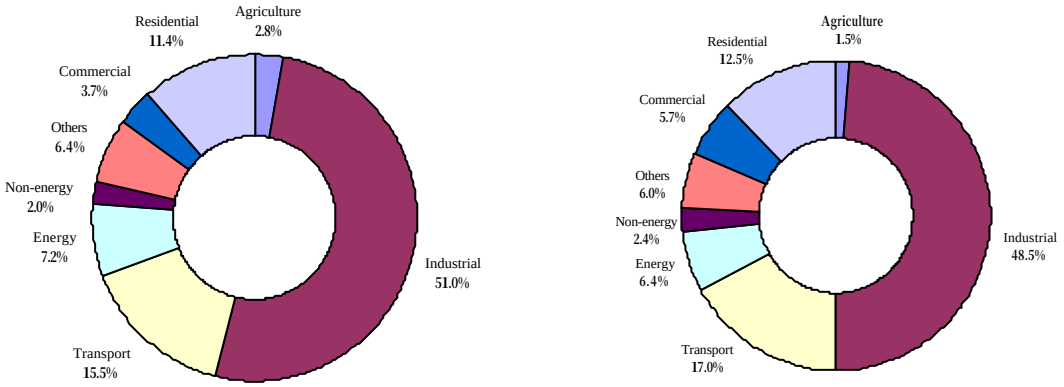


Figure 2. Taiwan's Energy Consumption Composition in 1990 & 2000
Source: Energy Commission, MOEA, Taiwan Energy Statistics Annual Report (2001)

The government of the Republic of China (Taiwan) is divided into three main levels: central, provincial/municipal, and county/city, each of which has well-defined powers. The central government consists of the Office of the President and five governing branches (called "Yuan") namely the Executive Yuan (Cabinet), the Legislative Yuan (Legislature), the Judiciary Yuan, the Examination Yuan, and the Control Yuan. Local governments comprise provincial, municipal, county and township governments. Laws must be passed by the Legislative Yuan after three readings and promulgated by the President. The interdepartmental agency "National Sustainable Development Council" led by the Vice Premier of the Executive Yuan, is the highest level body responsible for affairs related to the UNFCCC.

Chapter 2 Greenhouse Gas Emissions Inventories

In Taiwan's recent inventories of greenhouse gas emissions, estimates of CO_2 emissions were calculated in accordance with IPCC methodology. For estimates of CH_4 and N_2O emissions, real measurement data were used in addition to IPCC methodology. In credibility and accuracy, the estimate of CO_2 emissions is highest, while those for CH_4 and N_2O emissions are far lower and would require further research. The inventories of greenhouse gas emissions in Taiwan are shown in Table 2.

Table 2. Taiwan's CO_2, CH_4, and N_2O Inventories for 1990 (Thousand Tons)

GHG Source/Sink Categories	CO_2	CH_4	N_2O
Total Emissions (Net)	114,620	663.3	45.2
1. Energy (sectoral approach)	120,969	80.8	1.4
A. Fuel Combustion	120,969	9.6	1.4
B. Fugitive Emissions from Fuels	NE	71.2	0.0
2. Industrial Processes	11,547	0.2	0.6
3. Solvent and Other Product Use	NA	NA	NA
4. Agriculture	NA	119.5	41.6
5. Land-use Change and Forestry	-17,896	0.0	0.0
6. Waste	NE	462.8	1.6
7. Other	NE	NE	NE

Source: Statistics from Chapter 2

According to calculations using IPCC's reference approach, CO_2 emissions of fuel combustion in Taiwan totaled approximately 121.0 million metric tons, 0.5% of the world's total CO_2 emission in 1990. In the same year the corresponding per capita value was 5.57 metric tons, ranking number 24 in the world. The industrial sector emitted 55% of the total CO_2 from fuel combustion, 16% from the transportation sector, and 13% from the residential sector. Within the industrial sector, metal-based industries constitute approximately 30.2%, chemical industries 23.5%, non-metal mining industries 16.9%, textile industries 9.3%, wood and paper industries 6.3%, food industries 4.1% and others 9.7%. In 2000, the total CO_2 emission from fuel combustion increased to 229.8 million metric tons, equivalent to an annual growth rate of 5.5%, and the per capita emission was 9.8 metric tons.

Methane emission in the Taiwan area in 1990 was about 663.3 thousand metric tons, from which emissions from solid waste disposal were the biggest (67%). Next largest methane emissions were from rice cultivation (9%) and manure management (6%). In 1994, the total methane emissions reached 954.5 thousand metric tons, of which emissions from solid waste disposal constituted 75% and solid fuels 5.0%. The total methane emission in 2000 fell to 595.2 thousand metric tons, of which 59% from solid waste disposal on land, 13.0% from solid fuels, 6.7% from rice cultivation, and 6.1% from wastewater handling.

Nitrous oxide emissions in the Taiwan area in 1990 were about 45.2 thousand metric tons, from which emissions from agricultural and livestock activities were the largest (92%), and the next largest nitrous oxide emissions were from the waste sector (3.5%). The total nitrous oxide emission in 2000 was about 37.87 thousand metric tons, of which 87.0% from agricultural activities, 7.1% from the combustion of fuels, and 4.8% from the waste sector. Because of the continuous shrinking of local agricultural activities, nitrous oxide emissions have been decreasing year after year. However, recent studies reveal that the estimation was probably low on the emissions from agricultural activities and from the transportation sector. This estimation did not include the emission from digesters of residential wastes. Further investigations will be carried out soon.

On the emissions of other greenhouse gases, our government has been observing the international standards set by the Montreal Protocol to ban the imports and production of carbon fluorocarbon products (CFCs) since 1996. The government has also been tightening the control of hydrofluorocarbon products (HFCs) annually, aggressively promoting the recovery and reuse of CFCs, and enforces other measures such as prohibiting illegal imports. Greenhouse gases such as hydrofluorocarbons (HFCs), sulfur hexafluoride (SF_6) and perfluorocarbons (PFCs) are mainly emitted from industrial processes. The HCFCs emissions in 1998, 1999 and 2000 in Taiwan calculated by IPCC method are 17442, 16726 and 5612 thousand metric tons of carbon dioxide equivalents respectively. The PFCs emissions in 1998, 1999 and 2000 are 536, 1310 and 2721 thousand metric tons of carbon dioxide equivalents respectively whereas those values of SF_6 are 61, 99 and 114 thousand metric tons of carbon dioxide equivalents respectively.

Chapter 3 Impacts

With the natural environment of a subtropical island, Taiwan is very vulnerable to the impacts of climate change. In particular, the impacts would include sea-level rise, lack of water resources, primary industries, public health, ecosystems, etc. The direct impacts of sea-level rise would be the flooding of coastal lands, coastal erosion, and retreat of coastal front. Coastal communities would face the problems of relocation and subsequent social adaptation. The impacts on water resources would include the increase in frequency and extent of droughts, lack of water resources, and impacts on people's livelihood and industrial development. In addition, the increase in CO_2 concentration would enhance photosynthesis of plants and promote forest and

agricultural growth. However, it would also promote the growth of pests and propagation of disease vectors.

According to related research on the impacts of sea-level rise in the Taiwan region, flooding scenarios of the Tsang-Wan River delta and the I-Lan sedimentary plain were modeled for rising levels of 0.5, 1, and 1.5 meters. The results show that flooded area in the An-Ping district of Tainan City would reach 30.6%, 50.0%, and 72.5%, respectively, and in the Wu-Jiage area of I-Lan the flooded areas could reach 13.0%, 27.2%, and 40.2%, respectively. In addition, using the Chia-Nan plains as a case study, with sea level rises of 1, 2, 3 and 4 meters, the flooded coastal area of Tainan could reach 119.1, 162.7, 207.4 and 253.1 km^2, respectively. The flooded coastal area in Chiayi could reach 51.9, 75.8, 99.8, and 121.4 km^2, respectively.

Regarding the impacts on water resources, our academic research statistics found that between 1953-1990, the amount of annual rainfall in northern and eastern Taiwan showed an increasing trend, while that in central and southern parts showed a decreasing trend. The number of days of no rain in southern part also had an increasing trend. According to a 1995 estimate by the Water Resource Bureau, the amount of runoff in Taiwan would decrease by 4% by 2050, and possibly by 4.4% during the driest year.

Regarding the impacts on agriculture and forestry, our research shows that if increasing CO_2 concentration causes a rise in temperature and decrease in rainfall, corn production would decrease by 10-20% and wheat production by 7-8%. In addition, if the temperature in Taiwan's terrestrial area increases by 1-4℃, high-elevation plant belts and fir belts could rapidly decrease in the distribution area, or even disappear; forest belts of hemlock spruce, dragon spruce, oak, and broad-leaf evergreens could rise in elevation. In recent years, the widespread decrease of Japanese eel (*Anguilla japonica*) catch in Taiwan could also be related to climate change. Moreover, when the temperature increases to 27℃, the estrus cycle of milk cows would be prolonged, estrus signs weakened, estrus period shortened, the gestation rate would decrease, and fetal death rate would increase. An increase of one degree over the optimal growth temperature for pigs could decrease their food intake by 5% and decrease their life weight by 7.5%.

Regarding the impacts on public health, the effects of climate change could bring about rapid growth in disease-carrying rodents and thus affecting public health. Furthermore, warming of the climate could increase concentrations of allergy sources (such as fungus and pollen), raising the rate and severity of asthma and hay fever. The portion of children with asthma in Taiwan has increase from 1.3% in 1974 to 5.08% in 1985, 5.8% in 1991, and 10.79% in 1994. Room dust and fungus are found to be the main sources of allergies. In central and southern Taiwan, dengue fever has usually occurred during summer and autumn. As a result of climate change, dengue fever is now spreading to the northern area, and in some cases it even occurred in December.

Regarding ecosystems, global warming and the rise of sea level would have direct and indirect impacts on aquaculture in the shallow seas of Taiwan. In addition, high water

temperature during the summer period could increase the rate of massive loss of oyster population in the western coast of Taiwan. According to our research, an increase of 10℃ in water temperature could increase biological reaction in fish by 6-10 folds; if the temperature changed by 2℃, it could change the reproductive season of fish, and higher temperature could cause fish to lay eggs early. If future climate change moves the warm belt north, it could also change the geographical distribution of fish species in Taiwan.

Chapter 4 Adaptation

Strategies to adapt to sea-level rise include: complete impact assessment of sea-level rise in the Taiwan region; coastal zone protection and protection from tides; establishing new drainage systems; reducing impacts from sea-level rise; protection of coastal wetlands and ecosystems; control of large-scale coastal development; obtaining experiences from international cooperation; planning assistance for those who cannot recover from industrial transition; delimitation of flood plain areas and implementation of flood insurance systems; and establishing monitoring systems.

The adaptation policy on the impacts of water resources with regard to development, utilization, management and protection includes: primary development of surface water and secondary development of groundwater; actively develop and combine efforts in distribution of water; fortify management in water rights and collection of water tariffs; strengthen water utilization management to raise water utilization efficiency; reinforce management, protection, and containment of water sources; modernize water table monitoring and database development, as well as research and development of water resource technologies. Measures for disaster prevention include: construction of flood prevention structures; strengthening maintenance management; establishment of disaster prevention and response mechanism; sustaining research in disaster prevention technology; and establishing engineering and non-engineering flood prevention measures. The drought prevention and emergency response include: establishment of drought prevention and response systems; promotion of related work on prevention and response; and devising future development goals and response measures.

Adaptation to impacts on industries of agriculture and livestock includes: early depiction of weather pattern as a result of climate change, and to plan and protect agricultural production regions; change in concepts on irrigation, promote rational fertilization methods and use of slow-rate fertilizer; accelerating growth of species adaptive to new environments; early prevention of possible new plant diseases; draft response measures to agriculture and livestock production affected by inclement weather and new climate; improvement on animal feed to reduce their excrements; and improvement on animal housing and feeding management, as well as research on technology of processing animal excrements.

The adaptation measures for public health include: monitoring and systematic investigation of diseases from air, drinking water, food and vectors; monitoring and investigation to understand

distribution of disease vectors; investigation and analysis on respiratory and cardiovascular diseases caused by air pollution; systematic extermination of sources of disease vectors; continuing improvement on air pollution problems; strengthening controls on toxic chemicals; establishment of hygiene and environmental protection engineering; reinforcing research and environmental protection education in diseases caused or accelerated by environmental changes; as well as preparation of public health response to impacts of environmental changes.

The adaptation measures for forest ecosystems include: integration of investigative information and establishing monitor systems on forest environments and land utilization; establishing temporal and spatial information management systems on forest ecology for decision-support tools; establishment of national land information system; establishment of forest land classification system; accelerating forestation; harvesting wood from commercial forestation zones and subsequent re-forestation, cultivation, and accelerating forest carbon fixation; encouraging utilization of renewable resources from wood.

Chapter 5 Policy and Measures

To attain overall policy objectives, the government has been following the reference emissions set by the National Energy Conference in addressing the reduction of greenhouse gases. According to the nature of emissions and reduction costs, various quotas would be set up and distributed among different sectors. The head agencies of the sectors would then set up specific and practical reduction schedule and immediate action plans to meet their quotas. In addition, overall considerations are given to the relationships among economy, environment and energy, to obtain the baseline information on greenhouse gas emissions, to project future scenarios, and to establish models to analyze economic growth and reduction cost. As for major development projects, the increase in carbon dioxide emission has to be considered in the environmental assessment. The government has also been investigating an emission trading system for greenhouse gases. The response policy to the reduction of greenhouse emission by the government will then include energy policy and adjustment of energy structure, industrial policy and adjustment of industrial structure, and the corresponding policy on environmental protection.

Under the policy and measures listed above, the government's response actions for different greenhouse gases are explained below. First, on the reduction of carbon dioxide, concrete measures in energy conversion, industry, transportation, agriculture, as well as residential and commercial sectors are explained as follows:

1. Energy Conversion Sector

   The objectives of the energy policy in the Taiwan area are to establish a free, orderly, efficient and clean system of energy supply while considering the existing environment, indigenous characteristics, innovations, popularity and feasibility. In addition, liberalization

and privatization of the energy industry would be promoted in order to build a comprehensive energy policy balancing energy, environment, and economic development. The main stakeholders are the electric power and petroleum companies and their measures on reduction of carbon dioxide emissions.

2. Industrial Sector

The reduction measures from the industrial sector are as follows: voluntary energy conservation, implementation of energy audit system, promotion of energy conservation action plans, guidance on waste reduction, promotion of incentives and price cuts, energy conservation technical services, clean production technical guidance, strengthening educational dissemination, promotion of joint implementation projects, and promotion ISO-14001 environmental management system.

3. Transportation Sector

The feasible measures on reduction from the transportation sector are as follows: elevating and setting energy consumption standards of vehicles, promotion of energy saving transportation, complete mass transit systems, promotion of fuel tax from gasoline sales, implementing strategy for transportation management system, and development of intelligent transportation system.

4. Agricultural Sector

The main tasks of the agriculture sector include forestry management, green projects for cities and communities, encouraging and subsidizing private forestation, promoting energy conservation of fishing vessels, and guidance on renewal of fishing vessels.

5. Residential and Commercial Sectors

The four measures taken by the residential and commercial sectors are as follows: raising standards on efficiency standards of electric appliances, strengthening energy indices of building shells, establishing certification of energy conservation for architects, and establishing total control system for energy consumption of buildings.

The concrete measures of our government to reduce methane emissions are:

1. Agricultural, Fishery and Livestock Sectors

Adjustment of water quantity and irrigation method such as intermittent irrigation; adjustment of quantity and method of organic fertilizer; developing drought resistant/bearing species that require less water; continuing dissemination of ban on burning of agricultural residues; assistance on correct method of agricultural residue treatment or processing

utilization technology; strengthening assistance on improvement, control and ban of livestock pollution sources; assistance on effective collection, treatment and re-utilization of livestock excrements. These measures are carried out to reduce methane emissions by decreasing excrement production, increasing the collection of methane and its utilization rate, as well as elevating the treatment technology of livestock excrements.

2. Wetland, Sea, River and Lake

Strengthen the control and enforcement of ban on sources of waste water pollution; decrease organic pollutants of sewage from cultivation and the excrements from cultivated animals; accelerate the construction of public underground sewage system; and restore polluted sea, rivers and lakes.

3. Landfill Treatment

Control methane emission from sanitary landfills; promote the recovery and utilization of methane from landfills; and promote building of waste incinerators.

The concrete measures by our government to reduce nitrous oxide emissions are:

1. Agricultural products

Adjustment of water permeation to control water content in soil (both wet and dry fields); correct usage and dosage of fertilizer; developing slow-rate fertilizer; cultivating species with high nitrogen utilization; continuing dissemination of ban on burning agricultural residues; assistance on correct method of agricultural residue treatment or processing utilization technology.

2. Livestock industry

Planning adjustment of livestock industry to adequate development scale; effective collection and treatment of animal excrements; improving treatment technology on animal excrements; increasing methane utilization; and improving formula for animal feed.

3. Environmental protection

Strengthening inspection and control of fixed pollution sources and collection of air pollution fees; and strengthening inspection and adjustment of mobile air pollution sources and collection of air pollution fees.

As for concrete measures to reduce other greenhouse gases, since July 1, 1989, the government has controlled chemicals that are destructive to the ozone layer in accordance with the Montreal Protocol. Greenhouse gases such as fluorochlorocarbons, tetrachlorocarbons, trichloroethane, halofluorobromo-carbons have been banned since January 1, 1996. As for sulfur hexafluoride, perfluorocarbons and hydrofluorocarbons, further relevant investigation on their

emission would be needed. The reduction response measures include: abiding by Phase 2 control timeline of the Montreal Protocol, promoting recovery and re-utilization of CFCs, importing and developing alternatives for HFCs and other substitute technology.

Chapter 6 Research and Development, International Cooperation and Exchange, Education and Dissemination

The government places great importance on research and development of science and technology. Since 1984, the funding has been over 1% of the GDP. In 1997, the funding amounted to 156.3 billion NT (approximately 5 billion US), reaching 1.9% of the GDP. The main agencies responsible for promoting the research on greenhouse gases and climate change are the National Science Council and other agencies such as the Environmental Protection Administration, the Council of Agriculture, the Central Weather Bureau, the Energy Commission, the Industrial Development Bureau, the Water Resources Bureau, and other agencies. The National Science Council promotes large-scale (integrated) and basic research, whereas the other agencies carry out respective administrative matters and policy research.

In order to grasp the latest development in the UNFCCC and other related information on climate change, the government has assigned the National Science Council, the Environmental Protection Administration and the Industrial Development Bureau the responsibility for updating relevant information.

The National Science Council is responsible for promoting systematic monitoring in Taiwan. As early as 1990, the International Global Atmospheric Chemistry Project (IGAC) under the International Geosphere-Biosphere Program (IGBP) conducted studies on background atmospheric chemistry in Taiwan. In 1998, the National Science Council commenced a large-scale project, 'Monitoring, Analysis and Simulation of Atmospheric Chemistry in Taiwan and Neighboring Regions'. This project aimed at studying the emission and absorption of greenhouse gases in the region, monitoring the background atmospheric chemistry and the radiation field, international cooperation on monitoring, exchange on information and numerical simulation. The monitor system for the atmospheric chemistry of Taiwan and the neighboring region has been established, and preliminary results were obtained.

On the participation of greenhouse gas reduction technology and climate change research, Taiwan is a full member of international research organization on 'global change'. For example, the Academia Sinica is a representative in the International Geosphere-Biosphere Program (IGBP), and the National Science Council is a member of the International Group of Funding Agencies of Global Change Research Projects (IGFA).

In December 1999, the National Science Council and the Energy Commission completed the 'Long-term Development Plan on Energy Technology'. The major points of this long-term plan

are:

(1) Research Directions

1. Energy conservation and increasing energy efficiency, including the technologies on energy conservation and energy efficiency;

2. Development and utilization of new energy, including renewable energy, new use of energy and energy from waste; and

3. Energy management technology, including drafting regulatory standards, rationalization of energy price structure, design of incentive mechanism, energy saving life style, studies on cost effectiveness, and social welfare consideration.

(2) Promotion Strategies

This includes augmentation of research organization and human resources, appropriating enough research budgets, coordinating, integrating and supervising measures, as well as enhancing application promotion and advancing international cooperation. It is hoped that through energy conservation, use of clean energy, and elevating the efficiency and management that our energy structure may be adjusted and carbon dioxide emission may be reduced.

Taiwan as an island is very vulnerable to environmental impacts resulting from climate change. For the past 30 years, Taiwan has been thriving on economic development to raise the quality of life. Meanwile, it has been lacking behind on the application research on environmental restoration, public health and ecological preservation. Hence, technical supports on subsidence, water resources development, protection of public health, and ecological restoration are very much in need. Furthermore, because Taiwan is highly dependent on imported energy, new and clean energy technologies are to be gradually developed and applied. However, the cost of such technology is very high, and it would be quite difficult to reach these goals. Hence, support is very much needed from advanced countries on new and clean energy technologies.

On participation in the UNFCCC, Taiwan had participated in the third and fourth inter-government negotiation committee in 1991 as a NGO observer before the signing of the convention. It also took part in the Earth Summit in 1992. Taiwan has participated in the SBSTA and SBI meetings since 1993 and the meetings of the Conference of the Parties since 1995. However, we have not been able to take part in the discussions or fully express our views.

The subject of climate change is of concern not only concerned by researchers in Taiwan, but also emphasized by educators in schools and society. The Environmental Protection Administration is responsible for establishing the environmental protection policy and the dissemination of related laws and regulations, advancement of environmental protection measures, and reinforcement of environmental education via schools and social institutions. In

1997, the EPA initiated the 'National Environmental Protection Program', outlining the objectives in three phases. The Science Education Department of the National Science Council is responsible for the promotion of research in environmental education, research in basic theoretical teaching and class curriculum, and studies on environmental concepts and behavior. The Environmental Protection Division of the Ministry of Education is assigned to promote 'school environmental education' and 'social environmental education'. Further, courses related to climate changes are being offered in colleges and universities to disseminate seeds of environmental education. Also, there are more than 50 civic environmental protection groups and organizations in Taiwan that are important providers of social education, forming the indispensable part in helping the government promote education on climate change.

Chapter One: Basic information

1.1 Population

The population of the Taiwan area in 1946, one year after the end of the Second World War was only 6.09 million. It rose to 15 million in 1971, exceeded 20 million in 1989, and totaled at 21.18 million in 1994. By the end of 2000, the population of the Taiwan area was 22.28 million (see figure 1.1). Figures show that the population of the Taiwan area has increased by 2.6 times in the past 50 years. The population is expected to reach 23.92 million in 2010, an increase of 1.64 million on the 2000 figure.

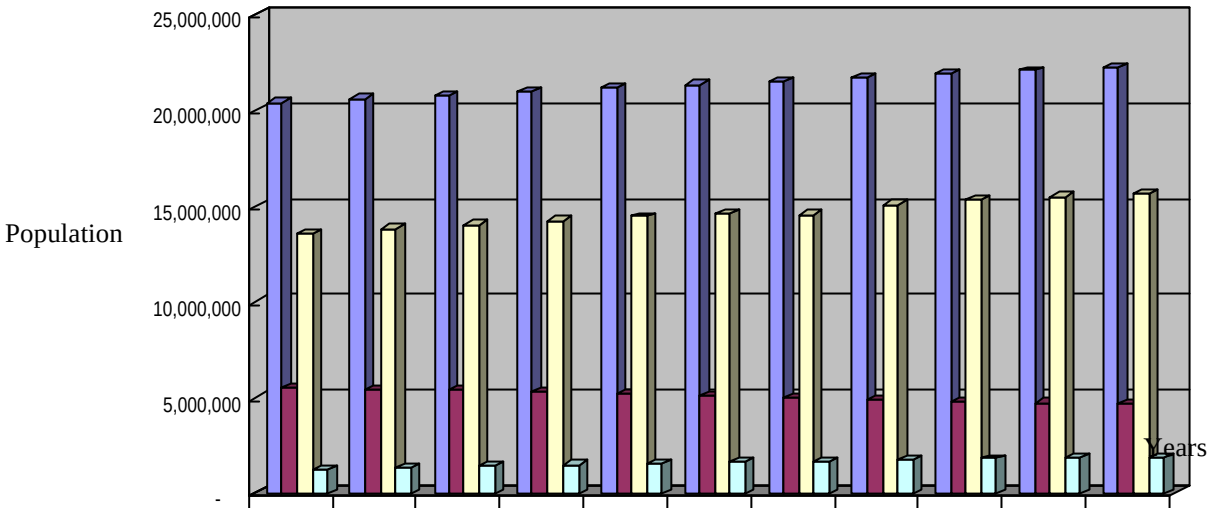
The population growth rate in 2000 was 0.834%. Population density was 617 people per square kilometer, the second highest in the world for nations with a population exceeding 10 million. Population density in the cities of Taipei and Kaohsiung was around 10,000 per square kilometer, roughly twice that of Singapore and Hong Kong. The urban population of the Taiwan area in 1998 accounted for 77.2 percent of the whole. Looking at the figures broken down by age-group, 21.1% were children (aged 0-14 years), a proportion that is declining, 70.3% were in the 15-64 year old age group, while 8.6 % were seniors aged 65 and over, a proportion that is increasing. Thus, Taiwan is gradually becoming an "old-aged" society. In 2000 the average life expectancy in the Taiwan area was 75.10 years – 72.54 years for men and 78.21 years for women. Analyzed for different areas, life expectancy was seen to increase with urbanization.

Analysis of the level of education received by Taiwan's population aged over six years in 2000 showed that 5.1% percent were illiterate or had studied outside schools. Those with only elementary level education accounted for 21.4%, those with secondary education (junior high, senior high and senior vocational schools) accounted for 52.1% and those with higher education 10.0%.

1.2 Geography

Taiwan is located off the southeastern rim of Asia, roughly 160 kilometers southeast of Mainland China. It comprises the island of Taiwan, the Penghu archipelago and another 86 islands and islets. Taiwan is bordered by the Pacific Ocean to the east and faces Fujian Province to the west across the Taiwan Strait. To the south is the Bashi Channel; the Ryukyu Islands are close by to the northeast. Taiwan's territory lies between 119 degrees and 124 degrees of east longitude and 21 degrees and 25 degrees of north latitude. The island of Taiwan is 377

kilometers long north to south and 142 kilometers east to west at its widest point. Taiwan has a total area of 36,006 square kilometers (including 39 square kilometers of reclaimed land).



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total	20,401,305	20,605,831	20,802,622	20,995,416	21,177,874	21,357,431	21,525,433	21,742,815	21,928,591	22,092,387	22,276,672
0-14 years old	5,525,365	5,427,150	5,361,347	5,279,705	5,169,581	5,076,083	4,982,543	4,914,280	4,815,400	4,737,596	4,703,093
15-64 years old	13,607,309	13,833,252	14,025,142	14,224,910	14,445,937	14,650,294	14,581,282	15,076,479	15,302,960	15,492,319	15,652,271
over 65 years old	1,268,631	1,345,429	1,416,133	1,490,801	1,562,356	1,631,054	1,691,608	1,752,056	1,810,231	1,865,472	1,921,308

Figure 1.1 Current population statistics for the Taiwan area
Source: Statistical Yearbook of the Republic of China（2001）

High mountains dominate the island of Taiwan. The central mountain range runs from north to south in the central and eastern parts of the island; the plain is in the west. The mountains rise steeply in the east and flat land occupies a narrow and restricted area. Roughly two thirds of land area is above 100 meters elevation; several peaks in the central mountain range surpass 3,000 meters. There are abundant forest resources; only one quarter of the land can be used for arable farming.

The island of Taiwan has 1,140 kilometers of coastline and 151 rivers. The central mountain range is the chief watershed; most rivers flow east or west into the Pacific Ocean or the Taiwan Strait respectively. Rivers are short; only six exceed 100 kilometers in length. The Choshui River is the longest at 186 kilometers. Steep topography, combined with the great difference between wet and dry seasons and the high degree of development mean that during torrential rain the water level can rise very rapidly and easily lead to disaster.

1.3 Climate

Taiwan is located between the world's largest landmass and its largest ocean. The Tropic of Cancer passes through the island of Taiwan, giving it a subtropical and tropical oceanic climate. High temperatures and rainfall and strong winds characterize the climate. Because of Taiwan's position in the Asian monsoon region, its climate is greatly influenced by monsoons as well as by its own complicated topography. The annual mean temperature in the lowlands is 22-25℃ and monthly mean temperatures exceed 20℃ for eight months starting April each year. The period from June to August is the hot season with mean temperatures 27-29℃. Temperatures are cooler between November and March; in most places, the coldest monthly mean temperature is above 15℃. The climate is mild rather than cold and temperatures only fall dramatically when a cold wave affects the region. The whole island has warmed over the past 100 years in line with the trend of global warming. The rate of warming was at 1.0-1.4℃/100 years. Warming was not only evident in urban areas: Yushan mountain and other areas without major development plans also displayed warming.

Average annual rainfall in the lowland parts of the Taiwan area is at a range of 1,600~2,500 mm. Due to the influences of topography and the monsoon climate, the rainfall differs greatly with different areas and seasons. In mountainous areas, average rainfall may exceed 4,000 mm per year. Rainfall is generally higher in mountainous areas than in lowland areas, higher in the east than in the west and higher on windward slopes than on the leeward side. The northeast monsoon prevails during the winter; this is the rainy season in the north though rainfall is not intense. But in the same winter period is the dry season in the south. During the summer, the southwest monsoon prevails, often giving rise to convective thunderstorms and bringing intense and copious rainfall. With added downpours brought by typhoons, this season often accounts for over 50% of annual rainfall in the south so that central and southern regions often suffer greatly. Relative humidity on the island of Taiwan, surrounded as it is by ocean, is high, usually measured at a range of 78~85%. In the north, relative humidity is higher during winter than during summer. The situation in the south is on the opposite. Over the past 100 years, the rainfall in the north has increased while the rainfall in the south has decreased. The trend is not as consistent as that of temperature change.

1.4 The Economy

In the half century since the end of the Second World War in 1945, the Taiwan area has created an "economic miracle" that has caught the attention of the world. It is now already joining the ranks of developed countries. Taiwan's economic development during these 50 years can be roughly divided into four periods: agricultural, light industry, heavy industry and technological. From 1946 to 1952, the country was suffering the destruction brought by war and industry was waiting for revival. To promote economic development, the government adopted a policy of using "agriculture to cultivate industry and industry to develop agriculture," as a way

to restore agricultural output. The land reform program during this period “reduced land rents”, “distributed public land”, and “purchased and resold land from large landlords”. This promoted vigorous agricultural development and led to the birth of an agricultural product processing industry, setting a foundation for economic development.

From 1953, the government implemented a series of economic development plans focused on industrial development. From 1953 to 1971, the nation’s economic development was focused on building up light industry. In the early period (1953-1960), priority was given to "import substitution" to boost the nation’s industrial production; during the later period (1961-1971), an "export promotion" policy was increasingly stressed, as a way to open up foreign markets. Subsequently, from 1972 to 1978, heavy industry developed at great speed as industrial development techniques and conditions reached maturity. But the speed of this development and Taiwan’s land shortage and high population density also put a great strain on the environment. After 1979, some labor intensive industries, such as food processing, leather goods production and apparel manufacture began to wither. From 1986, the industrial sector’s share of the economy began to decline while the service sector showed an upward trend. Meanwhile, the agricultural sector, while fluctuating year-on-year, broadly showed a downward trend in terms of the overall makeup of the economy. Thus it could be seen that the service industry was already becoming the lead player in the economy. As a consequence, the government, with a policy of “accelerating the upgrading of industry” and “developing strategic industries” as a guiding principle, promoted strategic industries that were low energy consumers, offered high added value, were high-tech and low-polluting, and had great export potential as a means to adjust the composition of Taiwan’s economy.

The nation’s rapid industrial development has led to continuous economic growth. In 1992, average GNP per person rose above US$10,000. In 1995, it was over US$12,000. In the 35 years from 1966 to 2000, excluding the five years 1974, 1975, 1982, 1985, 1998 when the economic growth rate fell below 5%, the economic growth rate ranged from 5.39% to 13.59%. See figure 1.2 for the trend in economic growth 1991-1998; key economic indicators can the government be seen in Table 1.1.

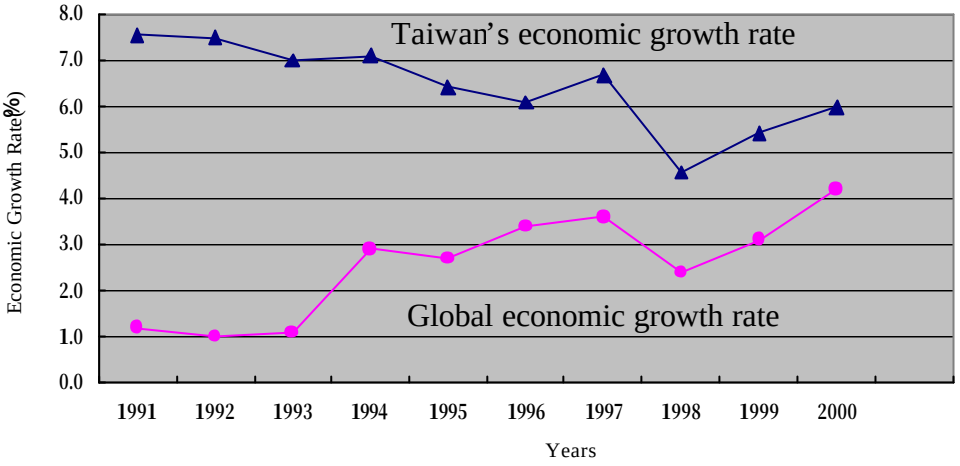


Figure1.2 Taiwan's economic growth rate 1991-2000

Source: Statistical Yearbook of the Republic of China（2001）
Annual Report on Economic Statistics for the Taiwan Area (2001)

Table 1.1 Key economic indicators for the Taiwan area

Year	Economic growth rate	Output and share of total output			
		Total (GDP)	Agriculture	Manufacturing industry	Service industry
	%	Million NTD	Share of total output %		
1989	8.23	3,938,826	4.90	42.30	52.80
1990	5.39	4,307,043	4.18	41.22	54.60
1991	7.55	4,810,705	3.79	41.07	55.14
1992	6.76	5,337,693	3.60	39.86	56.54
1993	6.32	5,874,513	3.66	39.00	57.34
1994	6.54	6,376,498	3.57	37.28	59.15
1995	6.03	6,892,046	3.55	36.24	60.21
1996	5.67	7,477,540	3.29	35.47	61.24
1997	6.77	8,131,152	2.73	34.93	62.34
1998	4.57	8,938,967	2.47	34.57	62.96
1999	5.42	9,289,929	2.56	33.19	64.25
2000	5.98	9,685,939	2.06	32.37	65.57

Source: Statistical Yearbook of the Republic of China（2001）
Annual Report on Economic Statistics for the Taiwan Area (2001)

As incomes have increased annually, since 1987, the share of the economy accounted for by service industry output has also risen. It passed 50% in 1989 and represented 65.6% of total economic output in 2000. In 2000, manufacturing industry accounted for 32.4% and agriculture accounted for just 2.1% of output, all-time lows for both sectors. Other social indices compiled since 1989, such as those on number and density of vehicles and factories, daily per capita refuse production and monthly water usage are given in Table 1.2. From the table it can be seen that data such as those that are closely related to economic development all increased. This reveals that economic growth has also produced a continually growing strain on the environment.

Table 1.2 Social indices for the Taiwan area

Year	No. of registered vehicles (million vehicles)	Density of vehicles (No. per Km^2)	No. of registered factories	Density of factories (No. per Km^2)	Refuse production (million metric tons)	Daily per capita refuse production (kg)	Monthly per capita water use (m^3)
1991	10.61	295	95,327	2.65	7.24	1.00	6.93
1992	11.27	313	94,673	2.63	8.00	1.09	6.93
1993	11.86	329	96,630	2.68	8.22	1.10	7.21
1994	12.38	344	95,581	2.66	8.49	1.12	7.15
1995	13.20	367	97,012	2.69	8.71	1.14	7.08
1996	14.27	396	96,820	2.69	8.63	1.13	7.30
1997	15.31	524	99,339	2.76	8.72	1.14	7.21
1998	1,592	442	98,836	2.74	888	1.14	7.07
1999	1,628	452	100,682	2.80	857	1.08	7.21
2000	1,702	470	98,861	2.73	786	0.98	7.25

Source: ROC Taiwan Area Environmental Protection Yearbook （2001）

1.5 Land use

The Taiwan area covers 36,006 square kilometers. The land is mainly covered by forestry resources, occupying 58% of land. Second comes agricultural land, occupying 25%. Other uses include urban construction, transport and water conservancy infrastructure, etc. A discussion of land utilization in each of these categories follows:

1.5.1 Forest

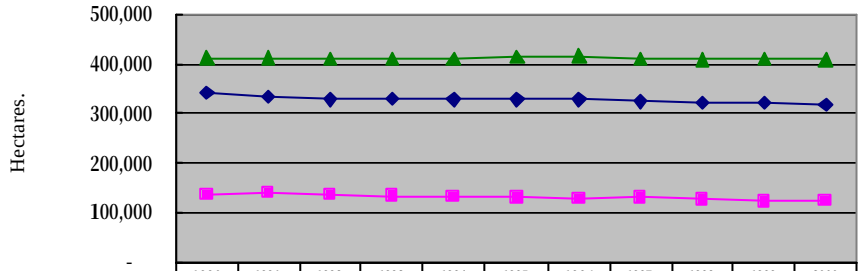
In 1954, forest covered 1.78 million hectares on the island of Taiwan. Between 1977 and 1994, forest coverage was maintained at about 1.86 million hectares. According to 1994 data, there were 2,102,400 hectares of forest covering 58.3% of the island of Taiwan. Broadleaf coverage accounted for 1,120,400 hectares or 31.19% of the island; coniferous trees covered 438,500 hectares (12.21%). There were 391,200 hectares of mixed coverage (10.8%) and 152,300 hectares of bamboo forest (4.24%). State-owned forest land (as opposed to publicly- and privately-owned land) was most abundant at 1,612,900 hectares. Since 1974, the

government has established six national parks, 23 forest reserves, 18 nature reserves and ten wildlife refuges to promote wildlife and environmental protection and preservation of rare plants and animals.

1.5.2 Agriculture

Taiwan's cultivated land can be divided into paddy fields and dry fields. Paddy fields can further be divided into single season cropping and two season cropping. In the early period, agricultural production emphasized raising productivity. In 1946, paddy fields covered 507,000 hectares. This area grew as irrigation facilities were extended. In the 1950s and 1960s, the area covered by paddy fields remained at around 530,000 hectares. After that the area covered gradually fell. With industrial development continuing apace, some agricultural land was adopted for non-agricultural purposes or for different crops. The area covered by paddy fields had dropped to under 500,000 hectares by 1984 and continued to fall. In 2000 there were just 442,000 hectares of paddy fields. Advances in farming technology meant that some formerly single season cropping fields now produce two crops per year. Consequently, the roughly 124,510 hectares of single cropping fields accounted for just 28.2% of all paddy fields in 2000, down from 41% in 1946. Statistics on the Taiwan area's cultivated land are shown in Figure 1.3

Figure 1.3 Cultivated land in the Taiwan area
Source: Taiwan Agriculture Yearbook (2001)



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Paddy Fields Two Crop	340,954	333,448	328,152	329,660	329,227	329,106	328,134	324,867	322,973	321,139	317,495
Paddy Fields Single Crop	136,043	139,311	136,864	133,900	131,999	130,229	128,034	129,998	127,643	123,317	124,510
Dry Fields	413,093	411,684	410,935	410,975	411,081	414,043	415,992	409,952	408,139	410,616	409,489

1.5.3 Livestock

The livestock industry of the Taiwan area has grown rapidly in the last 20 years. It has transformed from being a rural sideline occupation to being a capital and technology intensive industry. Pig and chicken rearing industries are most significant and have grown in size year by year. Cows are the major grazing livestock but numbers are very low. The more traditional duck rearing industry is also small. Since 1997, struggling to cope with foot and mouth disease in pigs and the imminent impact on the industry of WTO membership, the pig and cattle-raising sectors

have shrunk. It is anticipated that all parts of the livestock industry will be in prolonged decline for several years after WTO entry before they stabilize. In 2000, 9.9 million pigs, 389 million chickens, 24,505 head of cattle and 34 million ducks were slaughtered. Statistics on production of pigs, cattle, chickens, ducks and geese in the Taiwan area are given in Table 1.3.

Table 1.3 Livestock in the Taiwan area

Year	Pigs	Cattle	Chickens	Ducks	Geese
	Number slaughtered (1,000 head)				
1989	11,078.268	33.658	215,940	39,952	4,140
1990	12,121.873	27.328	226,556	39,900	4,777
1991	13,525.987	27.229	233,971	36,295	4,628
1992	13,310.000	29.573	257,666	40,558	5,683
1993	13,225.000	26.412	288,243	45,483	6,397
1994	13,860.000	28.829	301,914	40,886	8,521
1995	14,180.000	33.961	319,820	42,580	7,744
1996	14,310.000	33.168	345,509	41,759	7,078
1997	11,400.000	32.770	389,966	41,156	7,503
1998	9,800.000	29.377	389,524	35,719	7,955
1999	8,980.000	25.840	385,563	35,208	7,464
2000	9,990.000	24.505	389,770	34,099	6,503

Source: Taiwan Agriculture Yearbook (2001)

1.5.4 Fisheries

The fishery resources industry of the Taiwan area can be divided into fishing and aquaculture. The fishing industry can be subdivided into the inland, inshore, coastal and deep sea fishing industries; aquaculture can be subdivided into the inland and marine aquaculture industries. In 2000, the total fishing catch was 1.1 million metric tons; aquaculture covered 260,000 hectares. Statistics on fishery resources are given in Table 1.4.

Table 1.4 Taiwan area fishery resources

	Fishing catch					Aquaculture – area covered			Aquaculture
Year	Subtotal (1,000 MT)	Deep sea (1,000 MT)	Coastal (1,000 MT)	Inshore (1,000 MT)	Inland (1,000 MT)	Subtotal (1,000 ha)	Marine (1,000 ha)	Inland (1,000 ha)	Production (1,000 MT)
1951	79	16	23	39	1.1				
1956	151	44	60	45	1.5	37.4		37.4	42.4
1961	256	106	113	35	1.5	38.9		38.9	57.4
1966	367	169	168	29	1.2	38.1		38.1	58.5
1971	572	293	247	31	1.4	43.3	11.9	31.5	77.8
1976	675	325	314	33	2.6	54.0	14.1	39.9	135.5
1981	710	322	346	39	2.7	60.8	16.2	44.6	201.9
1986	828	463	306	57	2.2	65.4	15.0	50.4	266.1
1989	1122	734	334	50	3.9	71.1	16.1	55.0	249.8
1990	1111	767	292	48	3.5	76.4	18.1	58.3	344.3
1991	1024	714	267	41	2.3	74.1	15.8	58.3	291.9
1992	1066	738	281	45	1.8	72.3	14.0	58.3	261.6
1993	1139	835	259	43	1.7	71.0	14.4	56.5	285.3
1994	968	684	242	40	1.5	69.6	14.4	55.2	288.0
1995	1010	709	256	44	1.2	70.1	14.2	55.9	286.6
1996	967	669	257	41	0.4	67.6	15.4	52.2	272.5
1997	1037	748	248	41	0.4	63.2	14.6	48.6	270.2
1998	1093	839	210	44	0.5	63.2	14.1	49.1	255.2
1999	1101	855	206	40	0.6	63.2	14.0	49.2	263.1
2000	1100	886	170	44	0.6	62.6	13.6	49.0	256.4

Source: Taiwan Agriculture Yearbook (2001)

1.5.5 Mining

Mining resources are scarce in the Taiwan area. Economically viable mineral reserves can be categorized as energy reserves, metallic reserves, industrial raw materials and sand and stone.

1. Energy reserves

Energy reserves consist mainly of coal, oil and natural gas. Most coal is found in the north and center of Taiwan from Jinbaoli on the northeast coast stretching southwest to the Taan River. This area measures 120 kilometers north to south and is about 20 kilometers wide. Oil and natural gas are found mainly in the western foothills and lowlands.

2. Metallic reserves

The main metallic mineral reserves of the Taiwan area are of gold, silver, copper, iron sulfide and placer mineral. Main deposits are in the north and east, including Jinguashi, Dongao and Nanao in Ilan and Mugua River of Hualien.

3. Industrial raw materials

The industrial raw materials of the Taiwan area are principally non-metallic. They include limestone, marble, dolomite, clay, fireclay and salt. Salt production is chiefly along the southwest coast. The mining of limestone, clay and fireclay mining is concentrated in the west and south. Other minerals are mainly found in the east. Taiwan's limestone is mainly distributed in Kaohsiung County and City in the south and Taitung County in the east. More than 90% of production goes to making cement. Marble is mined in an area 150 kilometers long and 10 kilometers wide in Ilan, Hualien and Taitung Counties.

4. Sand and stone

Sand and stone can be categorized as river, land or marine depending on origin. A total of 21 rivers are mined. After extensive exploitation, land deposits are no longer sufficient to be mined. In the future, marine deposits may become the main source.

1.6 Transport

Taiwan's transport infrastructure was almost destroyed during the Second World War and left effectively paralyzed. Thereafter, the government made reconstruction a top priority and drew up comprehensive plans to restore the transport infrastructure. A large amount of money and manpower was invested, helping realize the successes of the present day.

1.6.1 Railways

A total of 81.53 million passengers took rail trips in 1952. In 1956, the number of rail rides rose to more than 100 million as rail transport continued to grow. Between 1961 and 1990, 120 million to 140 million rail trips were made annually. Numbers then began to rise again and they reached 460 million trips in 2000. Statistics for passenger rail transport in recent years are given in Table 1.5.

1.6.2 Road transport

The highway network of the Taiwan area currently includes the freeway network, round-the-island highway network, cross-island highways, longitudinal highway system, coastal highway system and the connecting highway system. At the time of Taiwan's retrocession in 1945, only around 7,000 miles of the highway network were passable due to war damage. In 1990, the mileage of the network rose to 20,042 kilometers in length. It reached 20,375 kilometers in 2000. The development of the highway system in Taiwan soon covered the whole island. Consequently, the highway network has become Taiwan's most important mass-transport system. Statistics for passenger and freight highway traffic in recent years are given in Table 1.6.

Table 1.5 Passenger rail transport in Taiwan

Year	Passenger transport		Freight transport	
	Number of passengers	Passenger kilometers	Tonnage (kilotons)	Kiloton-kilometers
1989	127,973,000	8,144,904,000	30,867	2,111,502
1990	132,392,000	8,322,568,000	28,054	1,877,264
1991	137,785,000	8,621,006,000	26,256	1,961,142
1992	149,877,000	9,361,405,000	28,194	2,139,956
1993	158,031,000	9,552,265,000	30,582	2,017,778
1994	160,992,000	9,515,174,000	31,233	2,006,711
1995	160,925,000	9,499,386,000	30,120	1,899,539
1996	171,263,000	9,032,420,000	27,410	1,584,857
1997	197,111,000	9,506,929,000	26,571	1,513,848
1998	233,339,000	10,305,456,000	26,560	1,404,355
1999	309,815,000	11,020,369,000	25,993	1,314,912
2000	460,311,000	12,623,814,000	22,261	1,179,056

Source: R.O.C. Transportation Statistics Monthly Report (2001)

1.6.3 Shipping

Taiwan has a maritime economy that relies heavily on imports and exports. As most exports depend on shipping, the port and harbor infrastructure has a major impact on national welfare and livelihood. The Taiwan area currently has four international harbors at Keelung, Kaohsiung, Taichung and Hualien and an auxiliary international harbor at Suao. The operations of the Taiwan area's harbor facilities are outlined in Table 2.10. Cargoes handled by Taiwanese ports and harbors showed a steady increase over the past decades. In 1952, 1,097 kilotons of import cargo and 762 kilotons of export cargo were handled. In 1996, 124,736 kilotons of import cargo and 20,969 kilotons of export cargo were handled. In 1952, 5,410 dead weight kilotons entered Taiwan's ports and 5,424 dead weight kilotons left the ports. In 1996 these figures rose to 445,268 and 446,695 dead weight kilotons respectively. Statistics for port facilities in the Taiwan area are given in Figure 1.4.

Table 1.6 Passenger and freight highway transport in the Taiwan area

Year	Passenger transport		Goods transport	
	No. of passengers	Passenger kilometers	Tonnage（kilotons）	Kiloton-kilometers
1989	1,690,170,000	25,741,288,000	244,389	11,493,933
1990	1,565,621,000	25,493,177,000	245,798	11,543,119
1991	1,502,476,000	25,329,460,000	254,297	11,813,756
1992	1,420,891,000	24,227,475,000	267,955	12,219,892
1993	1,355,556,000	23,275,043,000	301,669	12,866,835
1994	1,289,213,000	21,515,916,000	313,436	13,091,360
1995	1,203,451,000	19,388,680,000	291,176	12,491,503
1996	1,167,159,000	18,502,254,000	289,446	11,990,977
1997	1,162,800,000	17,509,620,000	276,980	12,165,071
1998	1,154,823,000	17,411,807,000	359,967	17,426,493
1999	1,149,146,000	17,518,392,000	349,661	18,469,537
2000	1,103,822,000	17,568,838,000	343,581	18,182,007

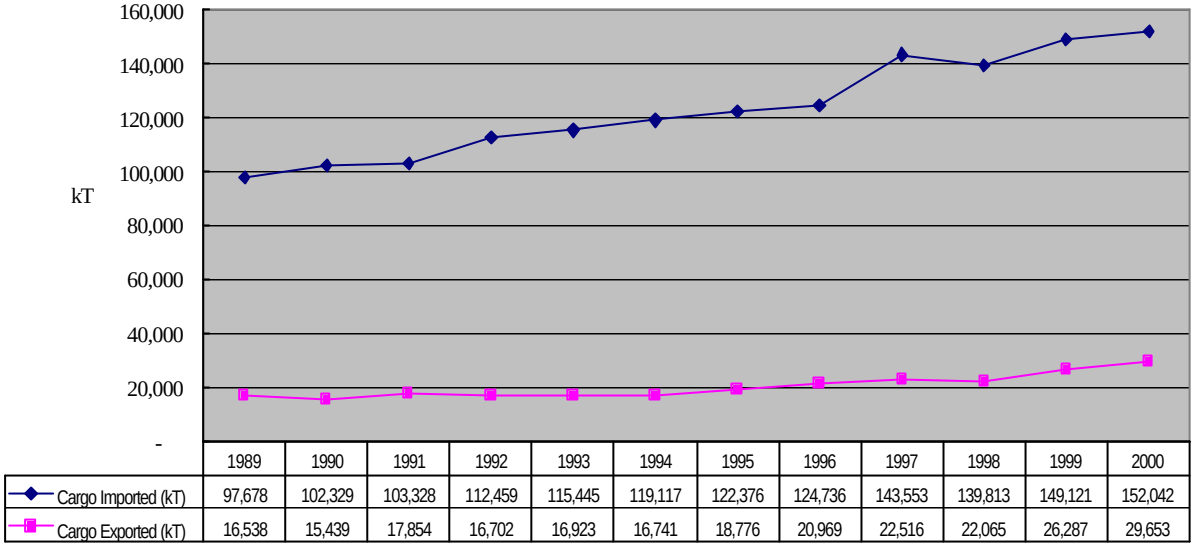
Source: R.O.C. Transportation Statistics Monthly Report (2001)

1.7 Energy

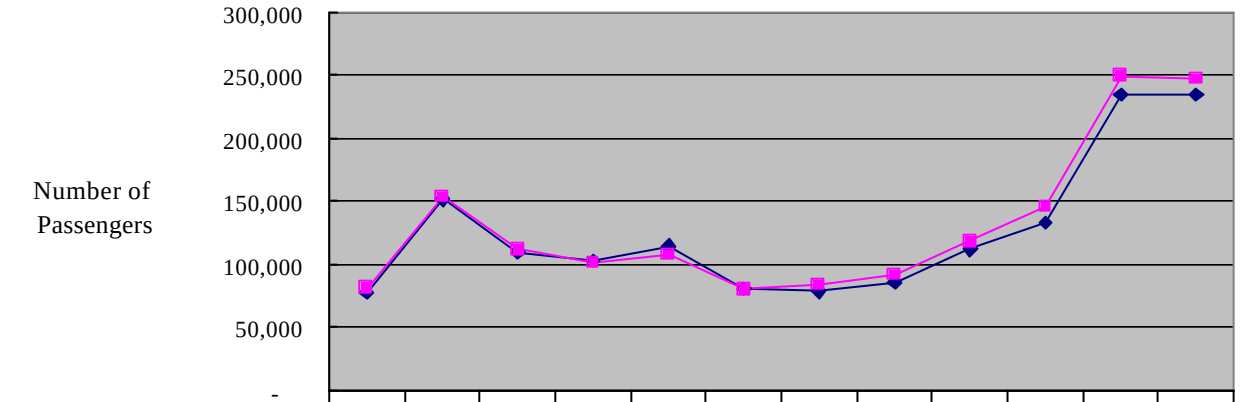
The increased demand for energy that has followed economic growth in the Taiwan area and the rise in living standards has been met, since Taiwan has meager energy reserves of its own, by imports. National reliance on imported energy rose from 77.3% in 1977 to 97.1% in 2000. Measures to diversify the Taiwan area' s energy sources reduced reliance on oil from the all-time high of 76.9% in 1977 to 51.4% in 2000. Oil supply relies almost entirely – over 99% – on imports. However, since the first global oil crisis, the government has diversified its sources for oil. Reliance on Middle Eastern oil has consequently fallen from 91.7% percent in 1977 to 60.3% in 2000.

1.7.1 Energy supply

The energy supply in the Taiwan area increased from 3 million kiloliters of oil equivalent in 1956, to 11.89 million kiloliters in 1970, 34.29 million kiloliters in 1980 and 106.23 million kiloliters of oil equivalent in 2000. About 51.4% of the total energy supply in 2000 came from petroleum; the second largest energy source was coal with a 28.9% share of the energy supply followed by nuclear power (9.8%), natural gas, including liquefied natural gas, (7.0%) and hydroelectric power (2.9%). Since 1969, a majority of energy has been imported; the proportion accounted for by domestic production has gradually diminished since then. In 2000, over 97% of energy sources were imported. Statistics on energy supply in recent years are given in Table 1.7.



	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cargo Imported (kT)	97,678	102,329	103,328	112,459	115,445	119,117	122,376	124,736	143,553	139,813	149,121	152,042
Cargo Exported (kT)	16,538	15,439	17,854	16,702	16,923	16,741	18,776	20,969	22,516	22,065	26,287	29,653



	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Number of Passengers Entering Port	77,441	151,414	109,685	102,682	114,455	80,239	78,315	85,862	111,541	132,602	234,252	234,429
Number of Passengers Leaving Port	81,005	153,735	111,893	101,358	107,456	80,111	83,392	91,311	118,075	145,898	249,357	247,144

Figure 1.4 Port facilities in the Taiwan area
Source: R.O.C. Transportation Statistics Monthly Report (2001)

A considerable portion of the energy supply is used to generate electric power. Details of Taiwan's electricity generating capacity are given in Figure 1.5. Coal-generated electricity output rose from 5,950 GWH in 1980 to 65,243 GWH in 2000, an increase from 14% to 35% of total electricity generation and an average annual increase of 14%. Fuel oil-powered generation has had a steady output of about 25,492 GWH, apart from in 1985 (5,420 GWH). In the period 1990 to 2000 fuel oil accounted for 14-24% percent of overall output. Liquefied natural gas (LNG) generation produced 1,035 GWH in 1990 and 16,580 GWH in 2000, an increase from 1% to 9% of total electricity generation. Nuclear powered generation produced 8,199 GWH in 1980 and 38,503 GWH in 2000. Nuclear powered generation reached a peak of 52% of the total supply in 1985 and has been falling since then. In 2000, it accounted for 21% of total electricity generation. Hydroelectric generation produced 2,926 GWH in 1980 and output increased to 8,870 GWH in 2000. In recent years, hydroelectric power has accounted for about 5~7% of the total. Power co-generation totaled 3,873 GWH in 1989 and rose to 30,222 GWH in 2000, an increase from 5% to 16% of the total. Looking at the overall breakdown of the country's electricity generating capacity, it is clear that coal-powered generation is increasing in importance. At the same time, demand for electricity continues to increase and possible growth in nuclear powered generating capacity is limited. In response to this, and facing a need to control CO_2 emissions, the government has promoted the use of clean energy sources such as natural gas as well as co-generation and increasing energy efficiency to minimize inappropriate energy use.

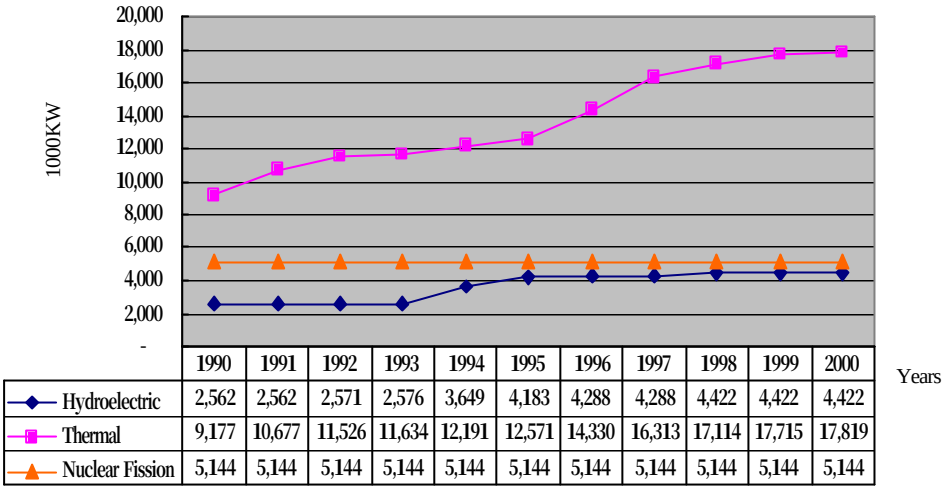
Table 1.7 Composition of domestic energy supply

Units: 1000 kiloliters oil equivalent

Year	Total	Domestically produced energy sources				Imported energy sources			
		Coal	Oil	Natural gas	Hydroelectric	Coal and related products	Oil and related products	LNG	Nuclear
1989	52,745	540	135	1,405	1,660	12,152	29,830	—	7,024
1990	58,605	325	182	1,304	2,034	13,357	32,297	941	8,164
1991	58,494	277	110	976	1,368	13,318	31,400	2,278	8,766
1992	64,124	231	72	846	2,074	15,986	34,129	2,379	8,407
1993	68,388	226	66	819	1,669	18,265	36,255	2,555	8,534
1994	73,034	196	69	898	2,207	19,292	38,512	3,199	8,662
1995	79,677	162	62	931	2,206	20,708	43,188	3,646	8,772
1996	83,230	102	60	891	2,247	22,376	44,458	3,779	9,387
1997	88,283	68	51	850	2,376	26,067	45,204	4,627	9,009
1998	92,458	55	54	869	2,635	26,650	47,429	5,619	9,147
1999	98,876	63	47	846	2,221	29,523	50,876	5,756	9,543
2000	106,227	57	37	739	2,203	32,644	54,601	6,382	9,564

Source: ROC Taiwan area energy resource index quarterly report (Third quarter, 2001)

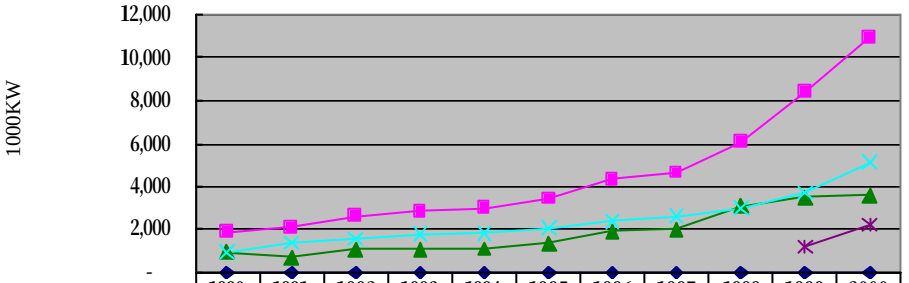
Taipower



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Hydroelectric	2,562	2,562	2,571	2,576	3,649	4,183	4,288	4,288	4,422	4,422	4,422
Thermal	9,177	10,677	11,526	11,634	12,191	12,571	14,330	16,313	17,114	17,715	17,819
Nuclear Fission	5,144	5,144	5,144	5,144	5,144	5,144	5,144	5,144	5,144	5,144	5,144

Years

Not Taipower



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Hydroelectric	4	8	8	9	8	8	8	8	8	8	3
Thermal	1,866	2,083	2,633	2,861	2,976	3,424	4,313	4,654	6,048	8,401	10,949
Standard Generation	940	700	1,080	1,061	1,126	1,358	1,932	2,002	3,081	3,484	3,561
Co-generation	926	1,383	1,553	1,801	1,850	2,066	2,382	2,652	2,968	3,717	5,138
Private Generation										1,200	2,250

Years

Figure 1.5 Electric power generating capacity

Source: Ministry of Economic Affairs Taiwan energy resources statistics yearbook (2001)

Apart from considering safety, environmental protection and economic factors, energy supply planning should make ample use of the flexibility offered by privately operated power companies and work out an appropriate balance with the public sector. At the same time, a sensible reserve capacity system should be put in place and power dispatching, distribution, operating stability and transmission facilities should be strengthened to raise the quality of the power supply. Concrete measures, such as expanding natural gas-powered generating capacity, encouraging co-generation projects, developing dual coal/oil fuel and gas power generator sets, strengthening the evaluation and development of small and medium scale hydroelectric generation, and speeding automation of power dispatching, ransmission and distribution to reduce accidents and transmission losses also increase the stability and quality of the power supply.

1.7.2 Energy Consumption

In 1956, Taiwan's energy consumption was 2.59 million kiloliters of oil equivalent. This rose to 9.87 million kiloliters by 1970, 29.57 million kiloliters in 1980 and 90.91 million kiloliters by 2000. Per capita energy consumption increased from 678 liters of oil equivalent in 1970 to 4,109 liters in 2000. Industry has been the largest energy consumer. Industrial consumption was 53.0% of the whole in 1956, increased to 61.5% by 1970 and then began to drop, falling to 55.3% by 1980 and 48.5% by 2000. With growth in vehicle numbers and demand for transport, the transport sector's demand for energy has also grown continually. From 9.8% of total consumption in 1956, transport grew to account for 17.0% of the total in 2000. Meanwhile residential use increased from 9.4% to 11.8%, commercial use from 3.6% to 5.7%, agricultural use fell from 4.2% to 1.5% and other uses dropped from 20.0% of the whole to 6.1%. The energy intensive petrochemical, iron and steel, cement and papermaking industries accounted for 64% of total industrial use and 1/3 of Taiwan's total energy consumption. However, these industries contribute only 7% of GDP. It is clear that with the current pattern of energy use by manufacturing industries, Taiwan faces pressure to reduce carbon dioxide emissions while maintaining the competitiveness of manufacturing industry; this is a major predicament for Taiwan as it works to reduce greenhouse gas emissions. Statistics for energy use in recent years are given in Table 1.8.

Table 1.8 Breakdown of energy consumption

Units: 1000 kiloliters oil equivalent

Year	Total	Energy user							Non energy use
		Energy sector	Industrial	Transport	Agricultural	Residential	Commercial	Others	
1989	49,289	3,472	25,648	7,412	1,389	5,610	1,642	3,094	1,021
1990	52,009	3,719	26,492	8,074	1,453	5,931	1,951	3,331	1,066
1991	55,187	3,803	27,839	8,630	1,405	6,513	2,271	3,586	1,160
1992	58,248	3,786	28,974	9,967	1,371	6,853	2,572	3,530	1,193
1993	61,575	4,030	30,133	10,877	1,412	7,315	2,888	3,627	1,293
1994	66,055	4,455	32,156	11,654	1,438	7,732	3,184	4,126	1,310
1995	68,964	4,651	33,364	12,330	1,491	8,279	3,437	4,136	1,279
1996	72,259	4,833	34,407	12,834	1,544	8,894	3,603	4,649	1,450
1997	76,845	4,962	37,952	13,166	1,442	9,116	3,908	4,772	1,528
1998	80,798	5,274	39,369	13,809	1,245	9,567	4,586	4,963	1,985
1999	85,261	5,617	40,883	14,522	1,305	10,721	4,914	5,057	2,244
2000	90,911	6,104	44,134	14,822	1,461	11,216	5,300	5,523	2,352

Source: ROC Taiwan area energy resource index quarterly report (Third quarter, 2001)

1.7.3 Energy Productivity

Table 1.9 shows the energy productivity based on purchasing power parities (PPPs, using 1990 prices in US$) of major countries. In 1990, Taiwan's energy productivity was US$ 5.06 and increased up to US$ 6.05 in 1999 (PPPs, using 1995 prices in US$). For the year 1999, the energy productivity of Taiwan was only lower than that of Italy (US$ 7.28), little higher than that of Japan (US$5.75), and far higher than those of France, UK, Germany, Korea, USA, and Canada. However, Taiwan has relatively little room for "economically effective" energy saving compared to other countries. Although the policy on the promotion of energy saving by government has achieved remarkable success, there is still some room for improvement.

Hence, in order to further reduce CO_2 emission, reduction measures in the energy sector must take the energy structure into consideration, in addition to the promotion of energy saving and energy efficiency.

Table1.9 Comparison on The Energy Productivity of The Main Countries in The World

Units: PPP (using 1990 prices in US$) / kilograms of oil equivalent

Countries / YEARS	ROC	Japan	France	Germany	UK	USA	Korea	Italy	Canada
1980	4.08	4.53	4.28	2.89	3.58	2.37	3.60	5.48	2.06
1981	4.61	4.79	4.40	3.00	3.67	2.48	3.87	5.63	2.18
1982	4.76	4.91	4.62	3.09	3.74	2.53	3.93	5.82	2.19
1983	4.50	5.02	4.56	3.15	3.88	2.62	4.06	5.91	2.27
1984	4.62	4.84	4.46	3.13	3.98	2.66	4.06	5.95	2.29
1985	4.76	5.04	4.34	3.10	3.90	2.72	4.11	6.04	2.36
1986	4.77	5.13	4.36	3.18	4.00	2.80	3.99	6.11	2.38
1987	5.19	5.28	4.36	3.21	4.14	2.75	4.11	6.08	2.40
1988	5.13	5.25	4.54	3.30	4.32	2.75	4.07	6.16	2.41
1989	5.06	5.30	4.41	3.47	4.40	2.80	4.08	6.08	2.40
1990	5.06	5.29	4.43	3.63	4.39	2.88	3.87	6.17	2.51
1991	5.01	5.37	4.23	3.82	4.19	2.84	3.88	6.08	2.46
1992	5.12	5.32	4.36	3.98	4.18	2.86	3.60	6.13	2.43
1993	5.11	5.29	4.22	3.97	4.22	2.86	3.40	6.13	2.41
1994	5.17	5.08	4.48	4.09	4.37	2.92	3.45	6.33	2.42
1995	5.16	5.01	4.41	4.10	4.44	2.96	3.42	6.20	2.44
1996	5.17	5.13	4.24	4.02	4.38	3.01	3.31	6.26	2.41
1997	5.22	5.13	4.46	4.16	4.64	3.11	3.24	6.26	2.47
1998	5.18	5.06	4.45	4.30	4.36	3.23	3.30	6.18	2.60
1999*	6.05	5.75	5.14	5.49	5.28	3.78	3.91	7.28	3.18

Source: Ministry of Economic Affairs (2000)；*IEA（2001），Units: PPP (using 1995 prices in US$) / kilograms of oil equivalent.

1.8 Government structure

The political system of the Republic of China (Taiwan) has four characteristics: "Sovereignty of the people," "Division of political rights and governing power," "Five power system" and "Balanced division of powers." The Constitution stipulates that the political powers are exercised by all citizens of the country; that governing power is shared by the president and five Yuans of the central government; a balanced division of power between central and local governments.

According to the Constitution, the president is the head of state and exercises powers in accordance with the Constitution. The president represents the nation in foreign affairs; is the commander-in-chief of the army, navy and air force; promulgates legislation and decrees; can proclaim martial law; can appoint and remove civil and military officials; can confer honors and decorations; can grant pardons, commutations and amnesties; and can conclude treaties, declare war and end hostilities in accordance with the Constitution.

The Cabinet (Executive Yuan) is the nation's highest executive body. It has a premier and vice premier. The premier is appointed by the president; the vice premier, ministers and chairmen are appointed by the president on the recommendation of the premier. The Cabinet is organized according to Article 3 of the Organic Law of the Executive Law. It contains ministries of the Interior, Foreign Affairs, National Defense, Finance, Education, Justice, Economic Affairs, and Transportation and Communications. The Cabinet also includes the Mongolian and Tibetan Affairs Commission and the Overseas Chinese Affairs Commission, which are also executive bodies. Following Article 5 of the same law, the Cabinet also contains the Directorate General of Budget, Accounting, and Statistics and the Government Information Office. Article 6 provides for the establishment of the Department of Health, Environmental Protection Administration, National Palace Museum, Mainland Affairs Council, Council for Economic Planning and Development, Vocational Assistance Commission for Retired Servicemen, National Youth Commission, National Science Council, Research, Development and Evaluation Commission, Council of Agriculture, Council for Cultural Affairs, Council of Labor Affairs, Public Construction Commission, Council of Aboriginal Affairs, and National Council on Physical Fitness and Sports. The Coordination Council for North American Affairs was set up under Article 14 of the same law. Other bodies within the Cabinet include the Central Personnel Administration, Central Bank of China, Atomic Energy Council, Fair Trade Commission, Consumer Protection Commission and Central Election Commission.

The Legislative Yuan is the nation's highest legislative body. It comprises popularly elected legislators who represent the people in exercising legislative power. The legislature has the power to decide by resolution upon matters such as statutory bills, budgetary bills, bills concerning martial law, amnesty, declaration of war, conclusion of peace, treaties and other important affairs of the state. Legislation passed by the legislature must be promulgated by the president before it formally becomes law.

The Judicial Yuan is the nation's highest judicial body. It supervises and administers judgments on civil, criminal and administrative litigation as well as disciplinary measures against public functionaries. The Examination Yuan is the nation's highest examination body. It supervises and administers civil service examinations, and has responsibility for all matters relating to appointments, qualification screening, performance evaluation, security of tenure, commendations and awards, pecuniary aid in case of death, retirement and the pensions of civil servants

1.9 Taiwan's organizational response to the Framework Convention on Climate Change

In order to respond to the requirements of the United Nations Framework Convention on Climate Change, the cross-ministerial "National Sustainable Development Committee" was set up under the leadership of the vice premier. This is the highest body set up by the government in response to the UNFCCC. Secondly, relevant ministries and commissions under the Cabinet have taken charge of certain aspects of the response, as detailed below:

1. Environmental Protection Administration: responsible for greenhouse gas reduction, international participation, strategy and legislation and for the "Atmosphere Protection and Energy Resources Working Group" of the National Sustainable Development Committee.
2. National Science Council: responsible for research relating to climate change and development of greenhouse gas reduction and recycling technology.
3. Ministry of Economic Affairs: the Energy Commission under the MOEA is responsible for changing the relative balance of Taiwan's energy sources, economizing on energy use, developing new energy sources and clean energy sources; the Industrial Development Bureau under the MOEA is responsible for promoting economical and more efficient energy use.
4. Council of Agriculture: responsible for advancing afforestation and reducing agricultural emissions of methane and nitrous oxide

In responding to the UNFCCC's CO_2 reduction standards, Taiwan has also given consideration to economic development, energy supply and environmental protection in order to aid sustainable national development. Since Taiwan's land area is restricted, natural resources are limited. Consequently, in the past, the development path of our manufacturing industries has largely followed the economic model of "reverse development" – starting with production of downstream primary consumer products, followed by the development of mid- and upstream high added value products. Since different sectors of the manufacturing industry can be mutually supportive, the overall composition of the industry should center on balanced overall development. Taiwan is currently upgrading its manufacturing industry, emphasizing high added value and high technology development as central. As a result, the degree of difficulty faced by Taiwan in reducing in greenhouse gas emissions through structural adjustment to industry and to the energy supply and increases in efficiency of energy use is far greater than

that for developed countries. Taiwan will consider itself to be a newly industrialized country not included in Annex 1.

Taiwan, responding to the December 1997 "Kyoto Protocol" to the United Nations Framework Convention on Climate Change and also giving consideration to economic development, energy supply and environmental protection, convened the National Energy Conference in May 1998. The conference discussed major topics: (1) UNFCCC development and response strategies, (2) energy policy and structural adjustment, (3) industrial policy and structural adjustment, (4) energy efficiency improvement and technology development, and (5) energy policy instruments.

Taiwan's principles for responding to UNFCCC are as follows:

1. The United Nations has already concluded and signed the UNFCCC and drawn up the Kyoto Protocol. Though not a member of the UN, as a member of the global community, Taiwan hopes to improve environmental protection and achieve sustainable development and hence should actively advance various "no regret" measures and further raise national competitiveness.
2. Taiwan's industrial sector is currently undergoing a stage of rapid structural adjustment. Taiwan should make every effort to establish itself as an emerging industrial nation. On the condition of there being no negative impact on economic development prospects, Taiwan should shoulder responsibilities following from the convention's four principles.
   (1) The Parties should shoulder common but differentiated responsibilities.
   (2) The specific needs and special circumstances of Parties should be given full consideration.
   (3) Policies to counter climate change should be economically effective and costs should be kept as low as possible.
   (4) The Parties have the right to promote sustainable development.
3. Baselines and projections for greenhouse gas emissions should give full consideration to the relationship with the economy, environment and energy resources; a model analysis of economic growth and cost reduction should also be set up.
4. Increases in carbon dioxide emission should be taken into account in environmental impact assessments of major development projects.
5. Taiwan will push ahead with an energy economizing project with a "no regret" strategy.

References

1. Directorate General of Budget, Accounting, and Statistics (Executive Yuan), 1999, Statistical Yearbook of the Republic of China
2. Chang-Hung Chou, 1999, Climate Change in Taiwan and an Assessment of the Impact of Global Climate Change – Climate, Report on Results of National Science Council (Executive Yuan) Case Study
3. Ministry of Economic Affairs Statistics Department, 2001, Annual Report on Economic Statistics for the Taiwan Area, R.O.C.
4. Environmental Protection Administration (Executive Yuan), 2001, Environmental Data for the Taiwan Area, R.O.C.
5. Environmental Protection Administration (Executive Yuan), 1998, R.O.C. Taiwan Area Environmental Protection Yearbook
6. Ministry of Transport and Communications Statistics Department, 2002, R.O.C. Transportation Statistics Monthly Report
7. Research, Development and Evaluation Commission (Executive Yuan), 1995, Introduction to the Work and Structure of the R.O.C. Government
8. Central Weather Bureau, 1994, Analysis and Projections for Climate Change in the Taiwan Area, R.O.C.
9. Ministry of Economic Affairs, 1998, Data from the National Energy Conference
10. Council for Economic Planning and Development (Executive Yuan), 1998, Sustainable National Development Forum
11. Taiwan Agriculture Yearbook, 2001.
12. IEA, Key World Energy Statistics from the IEA, 2001 edition.

Chapter Two: National Greenhouse Gas Inventories of Taiwan

2.1 Method and Its Uncertainty on Estimating the Emission of Greenhouse Gases by IPCC

The statistics and estimation of the emission of greenhouse gases practiced internationally are based on the 'IPCC Draft Guidelines for National Greenhouse Gas Inventories' (hereinafter referred to IPCC method) set by the Intergovernmental Panel on Climate Change, IPCC. In recent years, the statistics of greenhouse gas emission in Taiwan are also mainly based on the estimation by IPCC method, but some of the information also includes local measurements on emission. The reliability and accuracy on the estimation of carbon dioxide emission are high, but those of methane and nitrous oxide are relatively low. In addition, the statistics on emission of other greenhouse gases are not complete, yet. Furthermore, the government is also monitoring the emission of greenhouse gases and estimating the carbon dioxide removal capability of forests and offshore seawater.

In 1994, the IPCC method was passed after several consultations by the experts of IPCC and IEA in 1993, and further revised at a meeting of experts in 1995. The revised version announced in 1996 not only increases and amends the original estimation method but also specifies the quantified description of the accuracy on estimated data that the uncertainty of the data can be determined.

The IPCC method suggests that the governments calculate the emission and removal of important greenhouse gases according to the following 6 sectors:

1. Energy: the total emission of greenhouse gases by energy utilization includes the production of greenhouse gases on the use of fuels, the production, transportation, storage and transmission processes of energy, but not counting the part used in international bunkers.
2. Industrial Processes: not counting the emission from the use of energy, the total emission of greenhouse gases produced in industrial processes should be reported individually according to International Standard Industrial Classification of all Economic Activities.
3. Agriculture: the estimation of the emission of greenhouse gases according to agricultural activities does not include the estimation from the combustion of biomass fuels.
4. Land Use Change and Forestry: the emission and removal of greenhouse gases from the land use change and forestry.
5. Waste: the emission of greenhouse gases from landfills and treatment of wastewater.

6. Solvent and Other Product Use: the IPCC has yet to suggest the estimation method on the emission of non-methane volatile organic carbon (NMVOC) from the use of solvent and other materials containing volatile carbons.

The Information needed for estimating the emission of greenhouse gases by IPCC method includes two categories of activity data and the emission factor. In calculating the carbon dioxide emission from the combustion of fossil fuels, the activity data are the measurements of the quantity of all kinds of fossil fuels used, and the emission factor is the amount of greenhouse gases emitted from the technique used by individual fuels. The activity data may be taken from the official yearly statistical information from the government, or investigation should be carried out if this is unavailable. If the emission factor is not established, value suggested by IPCC may be used. But the value suggested by IPCC is a common value that would not reflect the special characteristics of individual country or area. Hence, IPCC encourages each participating government to carry out her own investigation that the local emission factor may be used to improve the accuracy of the information. In addition, IPCC requests all the reference materials of activity data and emission factor of each member government to be submitted for appraisal by its experts.

The main elements that were revised in the 1996 IPCC method of estimating greenhouse gases are as follows:

1. Energy: It provides method for simple calculation of Tier 1 gases excluding carbon dioxide and sulfur dioxide and Tier 1 calculation of sectoral emission of carbon dioxide, integrates calculating method for Tier 2 air vessels, incorporates the automobile manufacturers in the calculations on the sources, as well as suggests new emission factors for combustion of biomass fuels and mobile sources.
2. Industrial Processes: It adds new greenhouse gases to include hydrofluorocarbons (HFCs), hexafluoride sulfur (SF_6), perfluorocarbons (PFCs), ozone and aerosol precursors etc.
3. Agricultural Sector: It revises calculating units of nitrous oxide to incorporate nitrous oxide emission sources from soil and livestock, and modifies the emission factors and quantities of methane emission from rice cultivation.
4. Land Use Change and Forestry: It improves information contents in activity data including quality and quantity of biological materials on earth, forestry conversion rates, as well as adding calculation of carbon in soil.
5. Waste: It revises the definition of treatment (landfill, abandon, etc.), provides more data on ratios of degradable organic carbon in garbage, and modifies categorization of wastewater treatment such as industrial, commercial and residential waste water, etc.

Taiwan's Environmental Protection Administration (EPA) used the IPCC GHG Software (version 1.1) to estimate the 1990~2000 National GHG inventories and established an electronic database using the UNFCCC Common Reporting Format (UNFCCC CRF, v1.01).

Tables 2.1 through 2.5 are Taiwan's national greenhouse gas inventories in 1990, 1994, 1996, 1999 and 2000, respectively, showing anthropogenic emissions and removal by sink of carbon dioxide, methane, and nitrous oxide. Under the auspices of the EPA, the Energy Commission, and the Council of Agriculture, the emissions of carbon dioxide, methane and nitrous oxides in Taiwan area have been estimated using IPCC method as well as measurements. The estimation of carbon dioxide emission basically falls within the range of uncertainty mentioned in the IPCC method. On the other hand, the differences between the measurements and the IPCC estimation of methane and nitrous oxide are relatively large and need further investigation. In the tables, NA refers to "Not Applicable", indicating no such gas emission from that category; NE refers to "Not Estimated", indicating insufficient information or the statistical work is not completed; NO refers to "Not Occurring", indicating no emission activity from that category; and IE refers to "Included Elsewhere", indicating the calculation is listed under different category. The blocks in gray indicate that the estimation of that gas is not necessary for that category.

Table 2.1 Carbon Dioxide, Methane and Nitrous Oxide Emission Inventory of Taiwan in 1990

(Units : thousand metric tons)

GHG Emission Source and Sink Categories	Carbon Dioxide	Methane	Nitrous Oxide
National Total (Net) Emission	**114,620.19**	**663.27**	**45.16**
1.Energy	120,969.06	**80.75**	**1.43**
A. Combustion from Fuels （reference）	113,539.83		
（sectoral）	120,969.06	9.59	1.43
1. Energy Industry	46,185.55	1.21	0.64
2. Manufacturing Industries and Construction	43,740.31	3.22	0.54
3. Transport	22,329.07	4.12	0.19
4. Other Sectors	4,654.65	0.17	0.01
5. Other	4,059.48	0.87	0.05
B. Fugitive Emissions from Fuels	0.00	71.16	0.00
1. Solid Fuels	NE	37.32	0.00
2. Oil and Natural Gas	NE	33.84	0.00
2. Industrial Processes	**11,547.19**	**0.23**	**0.59**
A. Mineral Products	10,445.42	0.00	0.00
B. Chemical Industry	461.82	0.23	0.59
C. Metal Production	639.95	0.00	0.00
D. Other Production	0.00	NA	NA
E. Production of Halocarbons and SF_6	NA	NA	NA
F. Consumption of Halocarbons and SF_6	NA	NA	NA
G. Other	0.00	0.00	0.00
3. Solvent and Other Product Use	**0.00**	**NA**	**0.00**
4. Agriculture	**0.00**	**119.45**	**41.58**
A. Enteric Fermentation	NA	21.72	NA
B. Manure Management	NA	38.28	2.67
C. Rice Cultivation	NA	57.64	NA
D. Agricultural Soil	NO	0.00	38.87
E. Prescribed Burning of Savannas	NA	0.00	0.00
F. Field Burning of Agricultural Residues	NA	1.81	0.04
G. Other	NA	0.00	0.00
5. Land-Use Change and Forestry	**-17,896.06**	**0.01**	**0.00**
6. Waste	**0.00**	**462.83**	**1.56**
A. Solid Waste Disposal on Land	NE	445.33	NA
B. Wastewater Handling	NA	17.50	1.56
C. Waste Incineration	NE	0.00	0.00
D. Other	NE	0.00	0.00
7. Others	**0.00**	**0.00**	**0.00**
Memo Items：			
International Bunkers	**6,612.86**	**0.00**	**0.00**
Aviation	1,723.61	0.00	0.00
Marine	4,889.25	0.00	0.00
Multiple Operations	**NE**	NE	**NE**
CO_2 Emissions from Biomass	**NE**	**NA**	**NA**

GHG Emission Source and Removal	CO_2 Emission	CO_2 Removal	Net CO_2 Removal	CH_4	N_2O
Total Land-Use Change and Forestry	2,753	-20,649	-17,896	0.0	0.0
A. Change in Forest and Other Woody Biomass Stocks	501	-20,570	-20,070		
B. Forest and Grassland Conversion	2,252			0.0	0.0
C. Abandonment of Managed Lands	NE	-78	-78		
D. CO_2 Emissions and Removals from Soil	NE	NE	NE		
E. Other（Please Specify）					

Source: Environmental Protection Administration of the Executive Yuan（2001）

Table 2.2 Carbon Dioxide, Methane and Nitrous Oxide Emission Inventory of Taiwan in 1994

(Units : thousand metric tons)

GHG Emission Source and Sink Categories	Carbon Dioxide	Methane	Nitrous Oxide
National Total (Net) Emission	**152,988.84**	**954.47**	**50.14**
1.Energy	**158,842.81**	**103.94**	**1.78**
A. Combustion from Fuels （reference）	151,242.69		
（sectoral）	158,842.81	12.42	1.78
1. Energy Industry	69,865.42	1.45	0.81
2. Manufacturing Industries and Construction	50,268.07	3.77	0.63
3. Transport	29,959.72	5.74	0.27
4. Other Sectors	5,286.58	0.58	0.02
5. Other	3,463.02	0.88	0.05
B. Fugitive Emissions from Fuels	0.00	91.52	0.00
1. Solid Fuels	NE	48.63	0.00
2. Oil and Natural Gas	NE	42.89	0.00
2. Industrial Processes	**14,493.70**	**0.22**	**0.54**
A. Mineral Products	13,485.94	0.00	0.00
B. Chemical Industry	458.14	0.22	0.54
C. Metal Production	549.62	0.00	0.00
D. Other Production	0.00	NA	NA
E. Production of Halocarbons and SF_6	NA	NA	NA
F. Consumption of Halocarbons and SF_6	NA	NA	NA
G. Other	0.00	0.00	0.00
3. Solvent and Other Product Use	**0.00**	**NA**	**0.00**
4. Agriculture	**0.00**	**118.53**	**46.11**
A. Enteric Fermentation	NA	25.35	NA
B. Manure Management	NA	45.60	3.32
C. Rice Cultivation	NA	45.94	NA
D. Agricultural Soil	NO	0.00	42.75
E. Prescribed Burning of Savannas	NA	0.00	0.00
F. Field Burning of Agricultural Residues	NA	1.64	0.04
G. Other	NA	0.00	0.00
5. Land-Use Change and Forestry	**-20,347.67**	**0.01**	**0.00**
6. Waste	**0.00**	**731.77**	**1.71**
A. Solid Waste Disposal on Land	NE	713.18	NA
B. Wastewater Handling	NA	18.59	1.71
C. Waste Incineration	NE	0.00	0.00
D. Other	NE	0.00	0.00
7. Others	**0.00**	**0.00**	**0.00**
Memo Items：			
International Bunkers	**10,006.55**	**0.00**	**0.00**
Aviation	3,340.87	0.00	0.00
Marine	6,665.68	0.00	0.00
Multiple Operations	**NE**	NE	**NE**
CO_2 Emissions from Biomass	**NE**	**NA**	**NA**

GHG Emission Source and Removal	CO_2 Emission	CO_2 Removal	Net CO_2 Removal	CH_4	N_2O
Total Land-Use Change and Forestry	2,488	-22,836	-20,348	0.0	0.0
A. Change in Forest and Other Woody Biomass Stocks	155	-22,742	-22,587		
B. Forest and Grassland Conversion	2,333			0.0	0.0
C. Abandonment of Managed Lands	NE	-93	-93		
D. CO_2 Emissions and Removals from Soil	NE	NE	NE		
E. Other（Please Specify）					

Source: Environmental Protection Administration of the Executive Yuan（2001）

Table 2.3 Carbon Dioxide, Methane and Nitrous Oxide Emission Inventory of Taiwan in 1996

(Units : thousand metric tons)

GHG Emission Source and Sink Categories	Carbon Dioxide	Methane	Nitrous Oxide
National Total (Net) Emission	**169,349.37**	**871.08**	**51.38**
1.Energy	**175,426.10**	**117.90**	**1.95**
A. Combustion from Fuels （reference）	170,676.21		
（sectoral）	175,426.10	13.33	1.95
1. Energy Industry	83,480.68	1.61	0.97
2. Manufacturing Industries and Construction	50,313.05	3.66	0.58
3. Transport	32,325.35	6.31	0.30
4. Other Sectors	5,748.82	0.78	0.04
5. Other	3,558.20	0.97	0.06
B. Fugitive Emissions from Fuels	0.00	104.57	0.00
1. Solid Fuels	NE	54.17	0.00
2. Oil and Natural Gas	NE	50.40	0.00
2. Industrial Processes	**14,130.42**	**0.27**	**0.66**
A. Mineral Products	13,040.10	0.00	0.00
B. Chemical Industry	516.09	0.27	0.66
C. Metal Production	574.23	0.00	0.00
D. Other Production	0.00	NA	NA
E. Production of Halocarbons and SF_6	NA	NA	NA
F. Consumption of Halocarbons and SF_6	NA	NA	NA
G. Other	0.00	0.00	0.00
3. Solvent and Other Product Use	**0.00**	**NA**	**0.00**
4. Agriculture	**0.00**	**121.21**	**47.03**
A. Enteric Fermentation	NA	26.26	NA
B. Manure Management	NA	48.76	3.62
C. Rice Cultivation	NA	44.65	NA
D. Agricultural Soil	NO	0.00	43.37
E. Prescribed Burning of Savannas	NA	0.00	0.00
F. Field Burning of Agricultural Residues	NA	1.54	0.04
G. Other	NA	0.00	0.00
5. Land-Use Change and Forestry	**-20,207.15**	**0.15**	**0.00**
6. Waste	**0.00**	**631.55**	**1.74**
A. Solid Waste Disposal on Land	NE	608.94	NA
B. Wastewater Handling	NA	22.61	1.74
C. Waste Incineration	NE	0.00	0.00
D. Other	NE	0.00	0.00
7. Others	**0.00**	**0.00**	**0.00**
Memo Items：			
International Bunkers	**11,497.69**	**0.00**	**0.00**
Aviation	4,104.13	0.00	0.00
Marine	7,393.56	0.00	0.00
Multiple Operations	**NE**	NE	**NE**
CO_2 Emissions from Biomass	**NE**	**NA**	**NA**

GHG Emission Source and Removal	CO_2 Emission	CO_2 Removal	Net CO_2 Removal	CH_4	N_2O
Total Land-Use Change and Forestry	2,523	-22,730	-20,207	0.0	0.0
A. Change in Forest and Other Woody Biomass Stocks	170	-22,625	-22,455		
B. Forest and Grassland Conversion	2,353			0.0	0.0
C. Abandonment of Managed Lands	NE	-105	-105		
D. CO_2 Emissions and Removals from Soil	NE	NE	NE		
E. Other（Please Specify）					

Source: Environmental Protection Administration of the Executive Yuan（2001）

Table 2.4 Carbon Dioxide, Methane and Nitrous Oxide Emission Inventory of Taiwan in 1999

(Units : thousand metric tons)

GHG Emission Source and Sink Categories	Carbon Dioxide	Methane	Nitrous Oxide
National Total (Net) Emission	**206,385.60**	**960.01**	**43.64**
1.Energy	**206,385.60**	**151.70**	**2.41**
A. Combustion from Fuels （reference）	204,456.15		
（sectoral）	206,385.60	15.30	2.41
1. Energy Industry	106,583.37	1.99	1.27
2. Manufacturing Industries and Construction	57,739.13	4.24	0.67
3. Transport	34,993.28	6.97	0.32
4. Other Sectors	6,729.83	0.91	0.05
5. Other	339.99	1.19	0.10
B. Fugitive Emissions from Fuels	0.00	136.40	0.00
1. Solid Fuels	NE	70.07	0.00
2. Oil and Natural Gas	NE	66.33	0.00
2. Industrial Processes	**11,746.10**	**0.30**	**0.53**
A. Mineral Products	10,911.46	0.00	0.00
B. Chemical Industry	312.47	0.30	0.53
C. Metal Production	522.17	0.00	0.00
D. Other Production	0.00	NA	NA
E. Production of Halocarbons and SF_6	NA	NA	NA
F. Consumption of Halocarbons and SF_6	NA	NA	NA
G. Other	0.00	0.00	0.00
3. Solvent and Other Product Use	**0.00**	**NA**	**0.00**
4. Agriculture	**0.00**	**97.40**	**38.91**
A. Enteric Fermentation	NA	18.28	NA
B. Manure Management	NA	34.80	3.41
C. Rice Cultivation	NA	42.83	NA
D. Agricultural Soil	NO	0.00	35.46
E. Prescribed Burning of Savannas	NA	0.00	0.00
F. Field Burning of Agricultural Residues	NA	1.49	0.04
G. Other	NA	0.00	0.00
5. Land-Use Change and Forestry	**-20,437.23**	**0.01**	**0.00**
6. Waste	**0.00**	**710.60**	**1.79**
A. Solid Waste Disposal on Land	NE	684.18	NA
B. Wastewater Handling	NA	26.42	1.79
C. Waste Incineration	NE	0.00	0.00
D. Other	NE	0.00	0.00
7. Others	**0.00**	**0.00**	**0.00**
Memo Items：			
International Bunkers	**17,176.29**	**0.00**	**0.00**
Aviation	4,984.73	0.00	0.00
Marine	12,191.56	0.00	0.00
Multiple Operations	**NE**	NE	**NE**
CO_2 Emissions from Biomass	**NE**	**NA**	**NA**

GHG Emission Source and Removal	CO_2 Emission	CO_2 Removal	Net CO_2 Removal	CH_4	N_2O
Total Land-Use Change and Forestry	2,471	-22,908	-20,437	0.0	0.0
A. Change in Forest and Other Woody Biomass Stocks	141	-22,741	-22,599		
B. Forest and Grassland Conversion	2,329			0.0	0.0
C. Abandonment of Managed Lands	NE	-167	-167		
D. CO_2 Emissions and Removals from Soil	NE	NE	NE		
E. Other（Please Specify）					

Source: Environmental Protection Administration of the Executive Yuan（2001）

Table 2.5 Carbon Dioxide, Methane and Nitrous Oxide Emission Inventory of Taiwan in 2000

(Units: thousand metric tons)

GHG Emission Source and Sink Categories	Carbon Dioxide	Methane	Nitrous Oxide
National Total (Net) Emission	**218,488.86**	**595.20**	**37.87**
1.Energy	229,764.14	**111.72**	**2.70**
A. Combustion from Fuels （reference）	218,551.46		
（sectoral）	229,764.14	16.80	2.70
1. Energy Industry	120,172.94	2.14	1.47
2. Manufacturing Industries and Construction	63,544.92	4.79	0.78
3. Transport	35,601.04	7.08	0.32
4. Other Sectors	6,662.06	0.90	0.05
5. Other	3,783.18	1.89	0.08
B. Fugitive Emissions from Fuels	0.00	94.92	0.00
1. Solid Fuels	NE	77.15	0.00
2. Oil and Natural Gas	NE	17.77	0.00
2. Industrial Processes	**9,171.83**	**0.38**	**0.37**
A. Mineral Products	8,589.14	0.00	0.00
B. Chemical Industry	51.59	0.38	0.37
C. Metal Production	531.10	0.00	0.00
D. Other Production	0.00	NA	NA
E. Production of Halocarbons and SF_6	NA	NA	NA
F. Consumption of Halocarbons and SF_6	NA	NA	NA
G. Other	0.00	0.00	0.00
3. Solvent and Other Product Use	**0.00**	**NA**	**0.00**
4. Agriculture	**0.00**	**93.62**	**33.00**
A. Enteric Fermentation	NA	20.16	NA
B. Manure Management	NA	31.97	0.91
C. Rice Cultivation	NA	40.01	NA
D. Agricultural Soil	NO	0.00	32.06
E. Prescribed Burning of Savannas	NA	0.00	0.00
F. Field Burning of Agricultural Residues	NA	1.48	0.03
G. Other	NA	0.00	0.00
5. Land-Use Change and Forestry	**-20,447.11**	**0.00**	**0.00**
6. Waste	**0.00**	**389.48**	**1.80**
A. Solid Waste Disposal on Land	NE	353.11	NA
B. Wastewater Handling	NA	36.37	1.80
C. Waste Incineration	NE	0.00	0.00
D. Other	NE	0.00	0.00
7. Others	**0.00**	**0.00**	**0.00**
Memo Items：			
International Bunkers	**16,445.22**	**0.00**	**0.00**
Aviation	5,360.05	0.00	0.00
Marine	11,085.17	0.00	0.00
Multiple Operations	**NE**	NE	**NE**
CO_2 Emissions from Biomass	**NE**	**NA**	**NA**

GHG Emission Source and Removal	CO_2 Emission	CO_2 Removal	Net CO_2 Removal	CH_4	N_2O
Total Land-Use Change and Forestry	2,461	-22,908	-20,447	0.0	0.0
A. Change in Forest and Other Woody Biomass Stocks	133	-22,740	-22,607		
B. Forest and Grassland Conversion	2,327			0.0	0.0
C. Abandonment of Managed Lands	NE	-167	-167		
D. CO_2 Emissions and Removals from Soil	NE	NE	NE		
E. Other（Please Specify）					

Source: Environmental Protection Administration of the Executive Yuan（2001）

2.2Carbon Dioxide Emission Statistics

Carbon dioxide from the combustion of fossil energy is the main source of anthropogenic emission of greenhouse gases from all industrialized countries in the world, and Taiwan is no exception. In burning fossil fuels, carbon atoms are oxidized into carbon dioxide and emitted to the atmosphere. The carbon content of different fossil fuels differs from each other, so as the resulting carbon dioxide emission from the combustion of different fuels. Among different fossil fuels, coal has the highest carbon content whereas the carbon content of petroleum and natural gas accounts for 78 % and 59 % that of coal respectively.

Table 2.6 displays the total carbon dioxide emission of Taiwan in 1990 – 2000. Figure 2.1 shows the trend in Taiwan's carbon dioxide emission by main sectors in 1990 – 2000. According to Table 2.6 and Figure 2.1, the total carbon dioxide emission without LUCF was 132.5 million metric tons in 1990 and increased up to 238.9 million metric tons in 2000. From 1990 to 2000, it shows an increase of 80.3%. During the same period, carbon dioxide emission from the energy sector increased by 89.9% and that from the industrial processes sector decreased by 20.6%.

The emission from the energy sector is calculated from the Sectoral Approach of the IPCC method and the Energy Balance Sheet published by the Energy Commission. On the other hand, the calculations from the Reference Approach of the IPCC method show that the carbon dioxide emission from the combustion of fuels increased from 27.5 million metric tons to 73.1 million metric tons from 1970 to 1980, averaging an annual increase of 9.2 %. The carbon dioxide emission from combustion of fuels increased from 67.8 million metric tons to 111.5 million metric tons form 1980 to 1990, averaging an annual increase of 5.3 %. From 1991 to 2000, the carbon dioxide emission from the combustion of fuels increased from 113.5 million metric tons to 204.8 million metric tons, an average of 6.8 % increase each year. (Figure 2.2) Upon analysis, the per capita carbon dioxide emission of Taiwan is 5.58 metric tons in 1990, 7.60 metric tons in 1995, 8.99 metric tons in 1998, and 9.8 metric tons in 2000. From 1990 to 2000, the average annual rate of increase is 5.5 %.

Figure 2.3 shows the carbon dioxide from the combustion of fuels in Taiwan area in 1954 – 1999 according to different forms of fuels as in gaseous, liquid and solid states. The carbon dioxide emission from the combustion of gaseous, liquid and solid fuels in 1990 are 4.4, 66.4 and 42.8 million metric tons respectively whereas in 1999, the corresponding values are 13.4, 95.1 and 96.2 million metric tons.

In reference to the rules set by sectoral approach of IPCC, the carbon dioxide emission from thermal power generation is listed under energy industry. Accordingly, carbon dioxide emission from energy generation is the highest among energy industry (mainly comprised of refining petroleum as well as power generation). However, although thermal power plants are the main source of carbon dioxide emission, the power generated is mostly used in other sectors. If the carbon dioxide emission from thermal power generation is allocated to different sectors according to the capacity of electricity used (this method is not in accord with IPCC

method but can reflect the real carbon dioxide emission contributed by each sector), the new structure of carbon dioxide emission from different sectors is shown in Figures 2.4 and 2.5.

Table 2.6 Total Carbon Dioxide Emission of Taiwan in 1990 – 2000

(Units : thousand metric tons)

Sector / Year	Energy	Industrial Processes	Land-Use Change and Forestry	Total Emissions /Removals with LUCF	Total Emissions without LUCF
1990	120,969.06	11,547.19	-17,896.06	114,620.19	132,516.25
1991	130,500.97	10,467.35	-18,037.73	122,930.59	140,968.32
1992	138,232.78	13,039.26	-18,130.67	133,141.37	151,272.04
1993	149,136.03	15,099.41	-18,430.58	145,804.86	164,235.44
1994	158,842.81	14,493.70	-20,347.67	152,988.84	173,336.51
1995	165,277.69	14,132.34	-20,302.25	159,107.78	179,410.03
1996	175,426.10	14,130.42	-20,207.15	169,349.37	189,556.52
1997	188,508.48	14,927.19	-20,295.55	183,140.12	203,435.67
1998	203,149.14	12,937.30	-20,333.93	195,752.51	216,086.44
1999	206,385.60	11,746.10	-20,437.23	197,694.47	218,131.70
2000	229,764.14	9,171.83	-20,447.11	218,488.86	238,935.97

Source: Environmental Protection Administration of the Executive Yuan（2001）

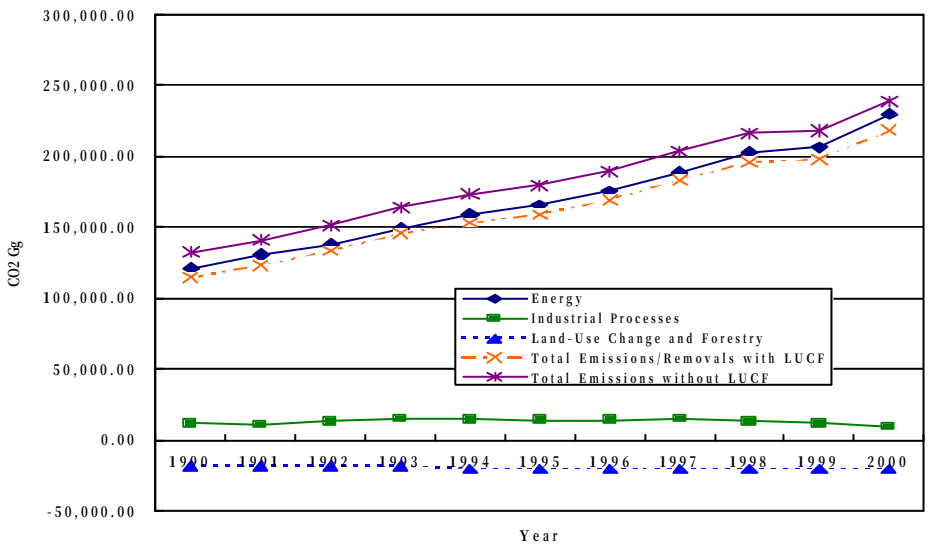


Figure 2.1 Trend in Taiwan's Carbon Dioxide Emission by Main Sectors in 1990 – 2000

Source: Environmental Protection Administration of the Executive Yuan（2001）

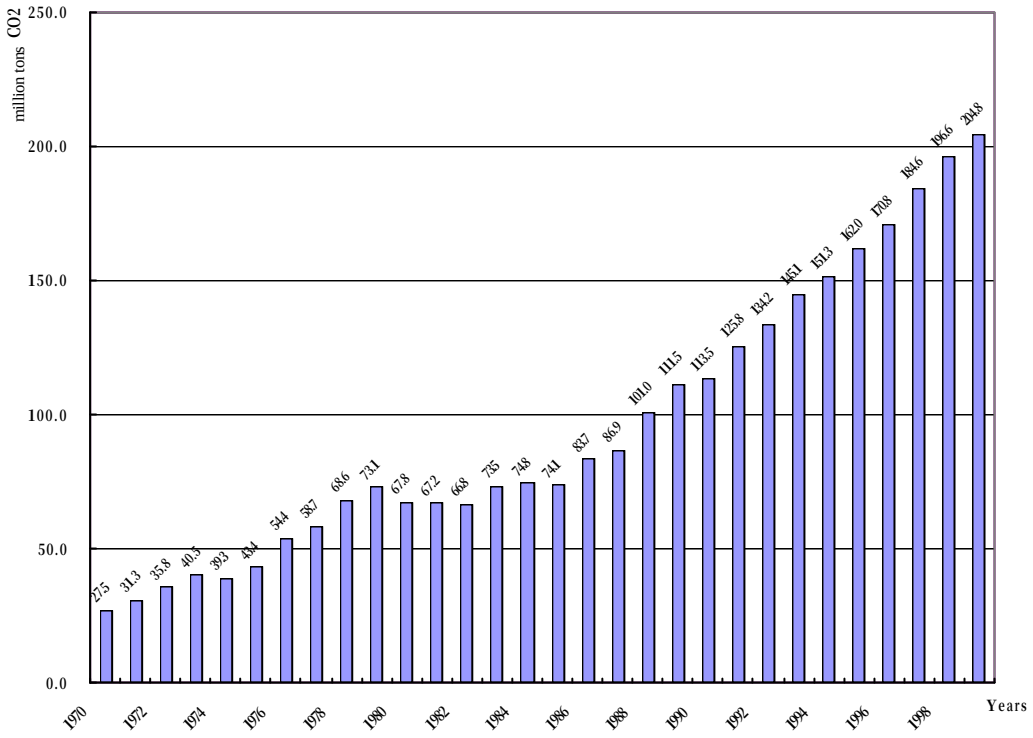


Figure 2.2 Total Carbon Dioxide Emission from Fuel Consumption in the Taiwan Area in 1970 – 2000 (million metric tons)
Source: Energy Commission of the Ministry of Economic affairs (2000)
Data from Emission Calculated from Reference Approach

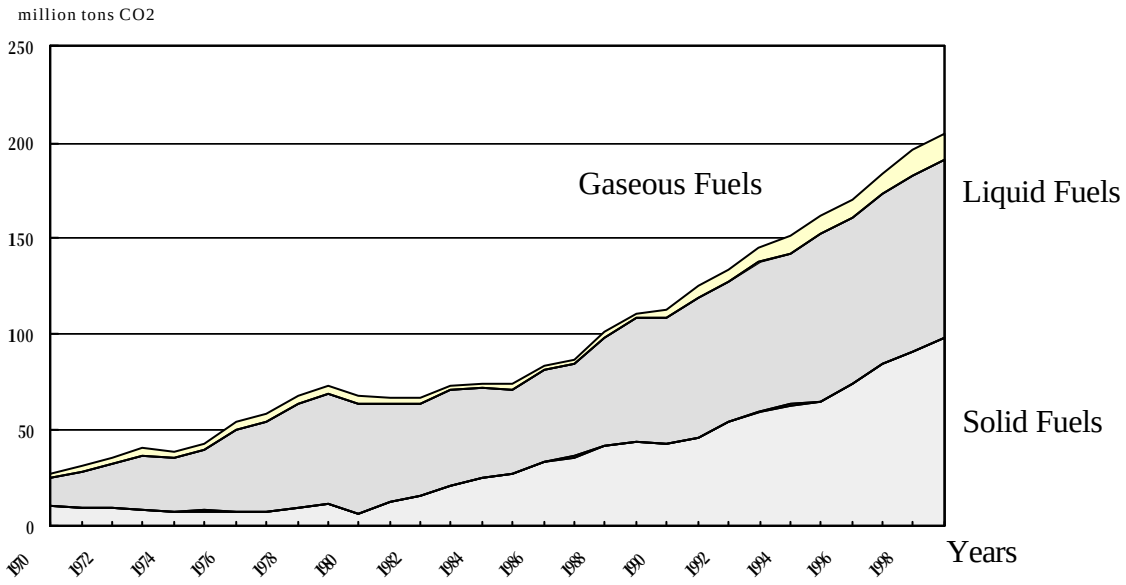


Figure 2.3 Trend in Carbon Dioxide Emission from Fuel Combustion in the Taiwan Area
Source: Energy Commission of the Ministry of Economic affairs (2000)

Figure 2.4 shows the carbon dioxide emission from fuel used by major sectors in the Taiwan area from 1970 to 1990. Figure 2.5 is the structure of carbon dioxide emission from energy utilization in Taiwan area in 1990 and 2000 according to different sectors.

In 1990, the carbon dioxide emission from the combustion of fuels from the industrial sector is 66.0 million metric tons accounting for 55 % of the total national emission. Among the carbon dioxide emission, 74 % is from direct combustion (steam generation and process heat) and 26 % is from power generation (driving motors, electric furnace and lighting). Besides, the transportation sector contributes 16 % of the total carbon dioxide emission, among which 60 % is from gasoline utilization and the rest is from emission from the combustion of diesel and aviation fuels. The emission from the commercial sector accounts for 13 % of the total emission with major emission from electricity utilization (67 %) and the rest is from the emission from combustion of natural gas, liquefied petroleum gas and fuel oil. The carbon dioxide emission from the agriculture, forestry, and fishing industry is about 3.7 million metric tons, accounting for 3 % of the total emission.

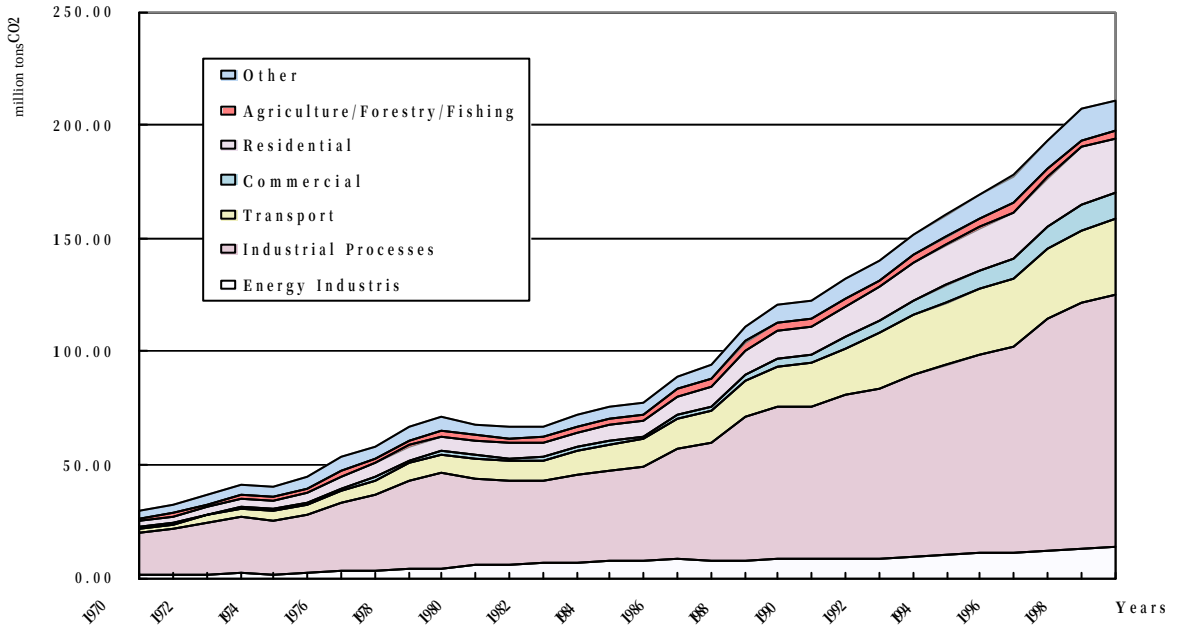
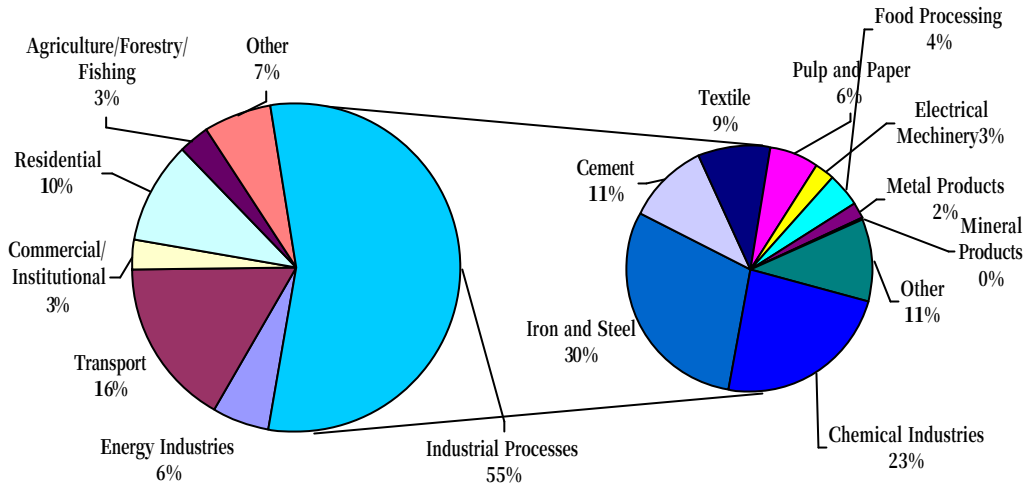


Figure 2.4 Trend in Carbon Dioxide Emission from Fuel Consumption by Main Sectors in the Taiwan Area

Source: Energy Commission of the Ministry of Economic affairs (2000)

Structure of Carbon Dioxide Emission from Energy Utilization of Taiwan in 1990



Structure of Carbon Dioxide Emission from Energy Utilization of Taiwan in 2000

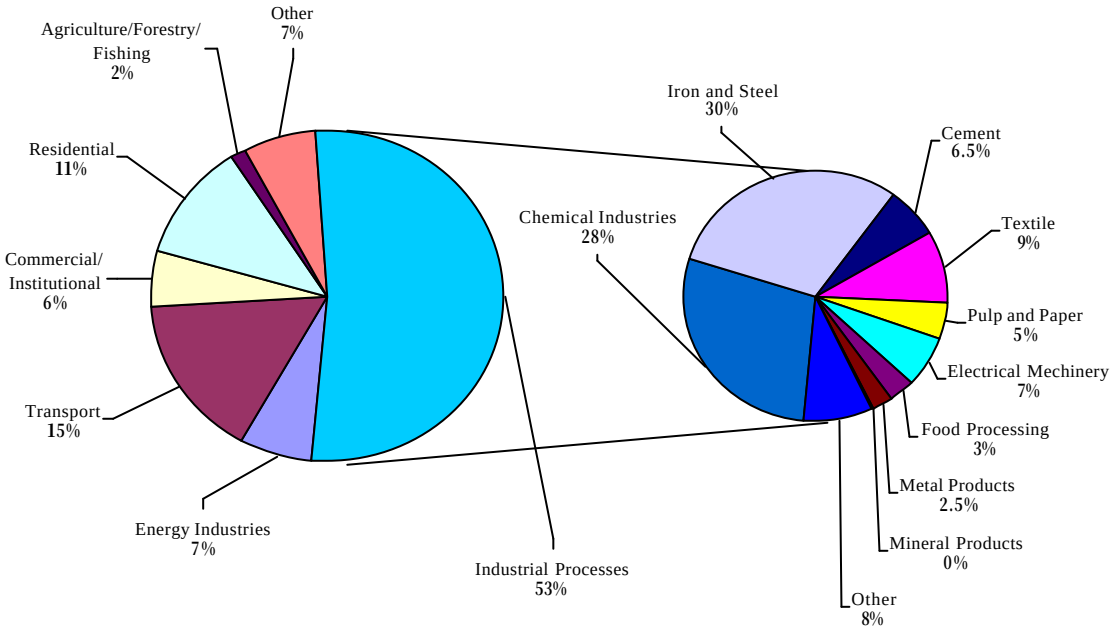


Figure 2.5 Structure of Carbon Dioxide Emission from Energy Utilization of Taiwan in 1990 and 2000 (Sectoral Approach)

Source: Energy Commission of the Ministry of Economic affairs (2000)

For the carbon dioxide emission from the industries in 1990, the iron and steel industry accounts for about 30 %, the chemical industry for about 23 %, the cement industry for about 9 %, the textile industry for about 9 %, the pulp and paper industry about 6 %, and the food industry for about 4 %. The carbon dioxide emission from different industries in 2000 still shows that iron / steel and chemical industries are the highest with about 30 % and 28 %, respectively, and textile and cement industries account for 9 % and 6.5 %, respectively.

2.3 Methane Emission Statistics

The main source of methane emission is from solid waste disposal on land and agricultural activities. Methane is produced from anaerobic fermentation of biological substances. This biological reaction is greatly affected by characteristics of local environments. Hence, in addition to using IPCC method, this statistics need inputs from local parameters. For the methane emission from the agriculture, forestry, and fishing industry in Taiwan, since the comprehensive information based on actual measurement of the area is not available except for some limited data from individual investigations used for reference only, this value is mainly estimated.

Table 2.7 lists the methane gas emission of Taiwan in 1990 – 2000. Figure 2.6 shows the trend in the methane gas emission of Taiwan. The total methane emission in the Taiwan area in 1990 was about 663.27 thousand metric tons. The largest emission was from solid waste disposal on land (67%), followed by emission from rice cultivation (9%) and emission from manure management (6%). It is seen in Table 2.7 that the total methane emission in the Taiwan area has increased year after year. In 1994, it reached 954.47 thousand metric tons, of which 75% was from solid waste disposal on land, 5.0 % from solid fuels, 4.8% from rice cultivation, and 4.77% from manure management. The percentage from the rice cultivation slipped because the cultivation area has decreased annually, thus resulting in the reduction of methane emission. The methane emission from the mining industry is mainly produced by imported coal. The total methane emission in 2000 fell to 595.2 thousand metric tons, of which 59.0% was from solid waste disposal on land, 13.0 % from solid fuels, 6.7% from rice cultivation, and 6.1% from wastewater treatment.

Since 1994, the methane emission from solid waste disposal on land has basically shown a falling trend. This should be related to the gradual shift of the main method of waste treatment to incineration in Taiwan. The main reason of the sharp fall of methane emission from manure management from 45.6 thousand metric tons in 1994, 48.8 thousand metric tons in 1996 to 34.8 thousand metric tons in 1999, and 32.0 thousand metric tons in 2000, is the outbreak of foot and mouth disease in the swine industry.

The methane emission from agricultural activities in the Taiwan area from 1990 – 2000 shows that except for the flourishing pig and chicken farming in earlier periods making both the number of animals farmed and methane emission reaching their respective highest points,

the population of the rest of agriculture, forestry, and fishing industries diminishes. Hence, the production from this industry gradually slipped, making methane emission from the agriculture, forestry, and fishing industries decreased respectively. As of 1997, the government ardently pursued to enter the World Trade Organization (WTO) and relative complementary policies such as encouraging farmers to leave the industry, practicing sabbatical farmlands, adjusting the use of farmlands, restructuring of the industry as well as changing the management modes are implemented. Further impacts such as the inability of exporting pork due to the outbreak of foot and mouth disease cut back the production of the agricultural, forestry, and fishing industries, and the methane emission. It is expected that after entering the WTO, Taiwan will experience continuing decrease in production of the agricultural, fishery and livestock industries for a few years and then level out to a stable situation. Hence, the methane emission from agricultural activities in the Taiwan area will predictably follow the same trend, first decreases and then stabilizes.

Table 2.7 Methane Emission of Taiwan by Main Sectors in 1990 – 2000

(Units : thousand metric tons)

Sector / Year	Energy	Industrial Processes	Agriculture	Land-Use Change and Forestry	Waste	Total Emissions
1990	80.75	0.23	119.45	0.01	462.83	663.27
1991	84.94	0.16	125.07	0.05	509.61	719.83
1992	91.30	0.15	119.77	0.01	625.69	836.92
1993	96.34	0.18	119.68	0.06	680.02	896.28
1994	103.94	0.22	118.53	0.01	731.77	854.47
1995	114.55	0.28	120.08	0.01	622.03	856.95
1996	117.90	0.27	121.21	0.15	631.55	871.08
1997	132.21	0.29	106.20	0.00	675.28	913.98
1998	145.36	0.22	96.51	0.01	677.54	919.64
1999	151.70	0.30	97.4	0.01	710.60	960.01
2000	111.72	0.38	93.62	0.00	389.48	595.2

Source: Environmental Protection Administration of the Executive Yuan（2001）

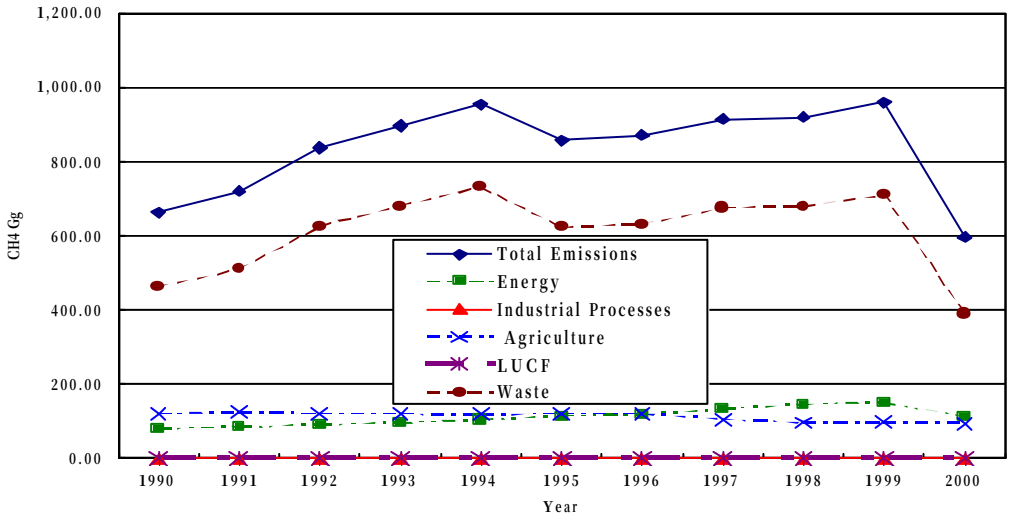


Figure 2.6 Trend in Taiwan's Methane Emission by Main Sectors in 1990 – 2000

Source: Environmental Protection Administration of the Executive Yuan（2001）

2.4 Nitrous Oxide Emission Statistics

The uncertainty is relatively large when using the IPCC method in estimating the nitrous oxide emission. Therefore, more reliable results can be obtained when both IPCC method and actual emission data obtained locally are used simultaneously. Table 2.8 is the nitrous oxide emission of Taiwan in 1990 – 2000. Figure 2.7 shows the trend in the nitrous oxide emission of Taiwan. The total nitrous oxide emission decreased from 45.16 thousand metric tons to 37.87 thousand metric tons from 1990 to 2000, showing a decrease of 16.1%. During the same period, the nitrous oxide emission from agriculture sector decreased 25.7% and that from waste sector increased 15.4%.

The total nitrous oxide emission of Taiwan in 1990 was about 45.16 thousand metric tons (see Table 2.8), of which the highest came from agricultural activities (92.0%), next was from waste sector (3.5%), and then from combustion of fuels (3.2%). The total nitrous oxide emission in 1994 was about 50.14 thousand metric tons, of which 92.0% came from agricultural activities, about 3.6% was from the combustion of fuels, and about 3.4% from waste sector. The total nitrous oxide emission in 1999 was about 43.64 thousand metric tons, of which 89% was from agricultural activities, about 5.6 % from the combustion of fuels, and about 4.1% was from the waste sector. The total nitrous oxide emission in 2000 was about 37.87 thousand metric tons, of which 87.0% came from agricultural activities, 7.1% from the combustion of fuels, and 4.8% from the waste sector. Because the agricultural activities continue to withdraw, the nitrous oxide emission from the agricultural sector also diminished by the year. In addition, the average families in Taiwan use anaerobic digestion to treat human wastes and thus produced nitrous oxide. This should be further studied in the future.

Table 2.8 Nitrous Oxide Emission of Taiwan by Main Sectors in 1990 – 2000

(Units: thousand metric tons)

Sector / Year	Energy	Industrial Processes	Agriculture	Waste	Total Emissions
1990	1.43	0.59	41.58	1.56	45.16
1991	1.42	0.63	44.39	1.58	48.02
1992	1.55	0.57	44.11	1.60	47.83
1993	1.69	0.59	45.11	1.61	49.00
1994	1.78	0.54	46.11	1.71	50.14
1995	1.81	0.63	45.83	1.73	50.00
1996	1.95	0.66	47.03	1.74	51.38
1997	2.11	0.74	40.76	1.76	45.37
1998	2.29	0.71	39.25	1.78	44.03
1999	2.41	0.53	38.91	1.79	43.64
2000	2.70	0.37	33.00	1.80	37.87

Source: Environmental Protection Administration of the Executive Yuan（2001）

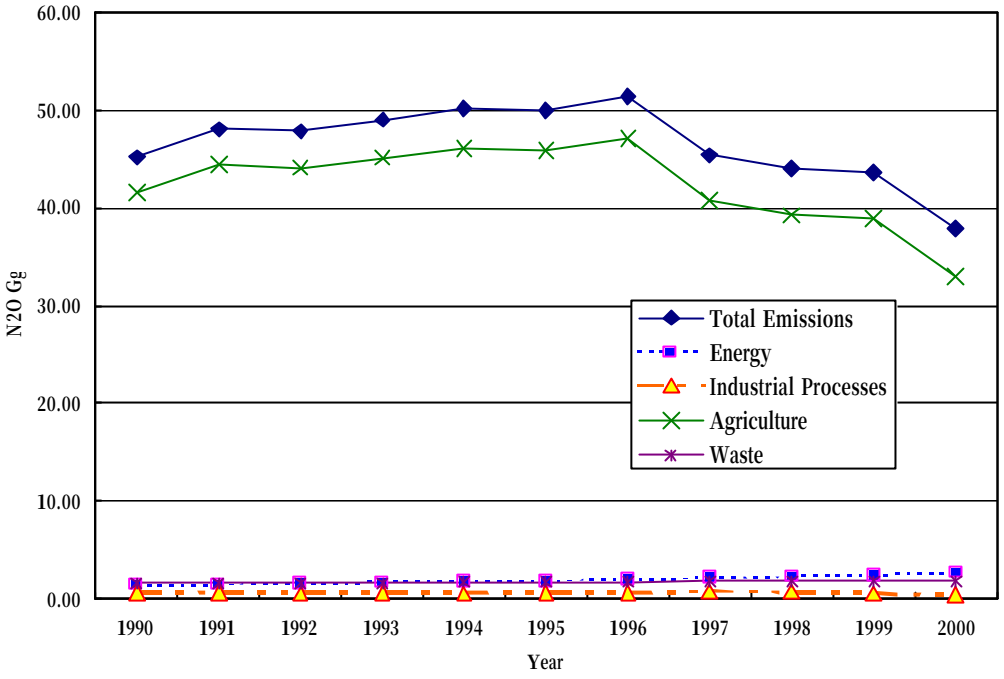


Figure 2.7 Trend in Taiwan's Nitrous Oxide Emission by Main Sectors in 1990 – 2000
Source: Environmental Protection Administration of the Executive Yuan（2001）

2.5 Sink and Monitoring

Using the IPCC method to formulate the amount of carbon dioxide absorbed by the forests in the Taiwan area, the net carbon removal can be calculated from the difference between the number of trees planted and the number of trees cut or the amount of wood consumed each year. Table 2.9 lists the information on the three investigations of forest resources in 1954, 1977 and 1994 in Taiwan. The total forest area in Taiwan in 1994 was 2,102,400 hectares, in which there were 1,120,400 hectares of broad leaf trees, 391,200 hectares of mixed coniferous/broad leaf trees, 438,500 hectares of coniferous leaf trees and 152,300 hectares of bamboo. The total storage volume was 358,744 thousand cubic meters, which 132,973 thousand cubic meters were from broad leaf forests, 99,401 hectares were from mixed coniferous/broad leaf forests, 125,835 thousand cubic meters from coniferous leaf forests, and 535 thousand cubic meters from bamboo forests with 1,127,831 thousand bamboos. According to the IPCC method, the carbon dioxide absorbed by the forests in Taiwan was 26.4 million metric tons in 1954, 19.8 million metric tons in 1977 and 22.6 million metric tons in 1994, not much change through these years (Environmental Protection Administration of the Executive Yuan, 2000). Please notice that the forestry area, and the area

of different types of trees were obtained by using different investigation methods. Hence, the change in the area of different types of trees did not necessarily represent the change in actual forest area. Using IPCC method, a recent study estimates the carbon dioxide absorbed by the forestry in Taiwan area in 1996 to be about 21.9 million metric tons, which was less than the previous estimation (Environmental Protection Administration of the Executive Yuan, 1998b). In addition, in estimating the carbon dioxide removal in sea waters and the dedicated economic area, the continental shelf can absorb 22.4 million metric tons, East Sea and the deep sea area of the Philippine Sea can absorb 41.4 million metric tons, and the deep sea area of the South Sea can absorb 42.9 million metric tons. The total carbon dioxide removal was about 106.7 million metric tons, with the uncertainty about 20 %.

Table 2.9 Forest Change in the Taiwan Area in 1954, 1977, 1994 and the Estimated Change in Carbon Dioxide According to IPCC Method

Year	Broad Leaf Forests (thousand hectares)	Broad/ Coniferous Mixed Forests (thousand hectares)	Coniferous Forests (thousand hectares)	Bamboo Forests (thousand hectares)	Carbon Dioxide Absorbed by Forests (thousand hectares)
1954	1,668	55.3	449.1	152.1	26.4
1977	1,158	157.5	416.7	133.5	19.8
1994	1,120	391.2	438.5	152.3	22.6

Source: Environmental Protection Administration of the Executive Yuan（2000）

The study sponsored by the National Science Council of the Executive Yuan is the main investigation on monitoring the greenhouse gas in Taiwan. Presently, the focus is on methane and nitrous oxide emission from wetlands, rivers, lakes, fishery ponds, dry farmlands, rice paddies and landfills (National Science Council of the Executive Yuan, 1999). On the other hand, the emission and monitoring of air pollutants such as NO_x, CO, NMVOC and SO_2, etc. are mainly performed by the Environmental Protection Administration of the Executive Yuan. In studying the reliability and the accuracy of the statistical information of the greenhouse gas emission in Taiwan, the relative statistical data of the information (not estimated, part or all) and the relative accuracy (low, medium, high) are investigated, and the results are listed in Table 2.10. It can be seen that the information on the carbon dioxide emission from the energy sector is most complete and detailed. Because the information is not sufficient, the errors on the emission of methane and nitrous oxide may be relative large and further investigations are needed to confirm the results.

2.6 Other Greenhouse Gases

Chlorofluorocarbons (CFCs) are substances that destroy ozone layer, and are also the greenhouse gases that raise the temperature of the surface of the earth. Taiwan observes the international regulations of 'Vienna Accord' and the 'Montreal Protocol' by strengthening the regulation on chlorofluorocarbons on schedule as well as promoting the recovery of these gases to be re-used. A hundred percent cutting rate was reached in 1996 and the import and production of such substances were totally banned. At present, hydrofluorocarbons (HCFCs) are also being under regulated on schedule.

The greenhouse gases added in the 1996 IPCC method and the 1997 Kyoto Protocol on 'International Accord on Climate Change' primarily are those used in the industrial processes such as HCFCs, SF_6 and PFCs, etc.. The emission inventory of alkyl halides and SF_6 of Taiwan in 1990 – 2000 is listed in Table 2.11. In Taiwan, the HCFCs and PFCs, are mainly used as the substitutes of chlorofluorocarbons in the refrigeration and air conditioning systems, semi-conductors manufacturing processes, high voltage circuit breakers and insulating gases of other breaking devices, foaming agents and fire extinguishers, etc. As shown in Table 2.11, the HCFCs emissions in 1998, 1999 and 2000 in Taiwan calculated by IPCC method are 17442, 16726 and 5612 thousand metric tons of carbon dioxide equivalents, respectively. The PFCs emissions in 1998, 1999 and 2000 are 536, 1310 and 2721 thousand metric tons of carbon dioxide equivalents, respectively, whereas those values of SF_6 are 61, 99 and 114 thousand metric tons of carbon dioxide equivalents, respectively.

2.7 Conclusion and Suggestion

It is shown in Table 2.12 that the total greenhouse gases emissions of Taiwan in 1990 – 2000 are transformed in the unit of thousand metric ton of carbon dioxide equivalent. Figure 2.8 is the trend of the total greenhouse gases emissions in Taiwan. Taiwan started the estimation of HFCs emission from 1992 and the emissions of PFCs and SF_6 from 1998. The total greenhouse gases emissions without LUCF in Taiwan showed a rising trend from 1990. In 2000, it increases up to 271622.24 thousand metric tons of CO_2 equivalent, of which 88.0% was from CO_2, 4.6% from CH_4 and 4.3% from N_2O. Carbon dioxide accounts for the largest emission among all greenhouse gases.

As shown in Table 2.13, the total greenhouse gases emissions of Taiwan by main sectors in 1990 – 2000 are expressed in the unit of thousand metric ton of carbon dioxide equivalent. Figure 2.9 shows the trend of the total greenhouse gases emissions of Taiwan by main sectors. Energy sector has the largest emission among all sectors. In 2000, 85.8% of the total greenhouse gases emissions in Taiwan was from the energy sector, 6.5% from industrial process sector, and 4.5% from agriculture sector.

Carbon dioxide emission was the largest greenhouse gas emission in Taiwan, and the main source of carbon dioxide emission was the combustion of fuels. This shows that the main

effort for future greenhouse gas reduction should be focussed on energy conservation and the promotion on the use of renewable energy.

Land-Use change and forestry sector was the sector that absorbs carbon dioxide. Because there is no obvious trend of change in forest area in Taiwan, the carbon dioxide absorbed by the forestry sector also shows trend of stability.

Solid waste disposal on land was the largest source of methane emission in Taiwan. As incineration becomes the main method of the treatment of waste in Taiwan, future methane emission should gradually diminish. Nitrous oxide emission mainly came from agricultural sector. As agricultural production in Taiwan continues to shrink, the nitrous oxide emission is expected to decrease gradually.

Because of the rapid growth in semi-conductor industry in Taiwan in recent years, the emission of hydrofluorocarbons (HCFCs), perfluorocarbons (PFCs) and hexafluoride sulfur (SF_6) was increasing rapidly accordingly. The potentials of greenhouse effects of these gases are high (several hundred to tens of thousands times that of carbon dioxide), the greenhouse gas emission from the semi-conductor industry should be noted.

Table 2.10 Greenhouse Gas Emission Source and Sink Categories, and the Uncertainty of Their Estimated Values

GHG Emission Source and Sink Categories	CO_2		CH_4		N_2O	
	Estimation	Accuracy	Estimation	Accuracy	Estimation	Accuracy
National Total (Net) Emission						
1. Energy	ALL	H	ALL	M	ALL	M
A. Combustion from Fuels（sectoral）						
1. Energy Industry	ALL	H				
2. Manufacturing Industries and Construction	ALL	H	ALL	M	ALL	M
3. Transport	ALL	H	ALL	M	ALL	M
4. Other Sectors	ALL	H	ALL	M	ALL	M
5. Other						
B. Fugitive Emissions from Fuels	ALL	H	ALL	M	ALL	M
1. Solid Fuels	ALL	H	ALL	M	ALL	M
2. Oil and Natural Gas	ALL	H	ALL	M	ALL	M
2. Industrial Processes	NE	NE	ALL	M	NE	NE
A. Mineral Products	NE	NE	ALL	M	NE	NE
B. Chemical Industry	NE	NE	ALL	M	NE	NE
C. Metal Production						
D. Other Production	ALL	H	NA		NA	
E. Production of Halocarbons and SF_6						
F. Consumption of Halocarbons and SF_6						
G. Other						
3. Solvent and Other Product Use	**NA**	**NA**			**NA**	**NA**
4. Agriculture	**NE**	**NE**				
A. Enteric Fermentation			ALL	H		
B. Manure Management			ALL	H	ALL	H
C. Rice Cultivation			ALL	H		
D. Agricultural Soil	NE	NE	NE	NE	ALL	H
E. Prescribed Burning of Savannas			NA	NA	NA	NA
F. Field Burning of Agricultural Residues			ALL	H	ALL	H
G. Other						
5. Land-Use Change and Forestry	**PART**	**M**	**PART**	**L**		
6. Waste						
A. Solid Waste Disposal on Land	NE	NE	PART	M		
B. Wastewater Handling			PART	M	PART	M
C. Waste Incineration	NE	NE				
D. Other						
7. Others						
Memo Items：						
International Bunkers	**ALL**	**H**	**ALL**	**M**	**ALL**	**M**
Aviation						
Marine						
Multiple Operations	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
CO_2 Emissions from Biomass	**NE**	**NE**	NA	NA	NA	NA

Remarks:

Relative Estimation：(1) ALL (Data > 90%)，(2) PART，(3) Unaccounted : BLANK

Relative Accuracy ：(1) High：H (error <10%)，(2) Medium：M(10-50%)，(3) Low：L(>50%)。

Source: Environmental Protection Administration of the Executive Yuan（2001）

Table 2.11 Halocarbons and SF_6 Emission of Taiwan by Main Sectors in 1990 – 2000

(Units: thousand metric tons of carbon dioxide equivalent)

GHG Emission Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total (Net) HCFCs Emission	**NE**	**NE**	**702.00**	**1,638.00**	**1,521.00**	**1,755.00**	**2,808.00**	**3,276.00**	**17,442.0**	**16,726.0**	**5,612.00**
1.Energy											
2. Industrial Processes	**NE**	**NE**	**702.00**	**1,638.00**	**1,521.00**	**1,755.00**	**2,808.00**	**3,276.00**	**17,442.0**	**16,726.0**	**5,612.00**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C. Metal Production											
D. Other Production											
E. Production of Halocarbons and SF_6	NO	NO	702.00	1,638.00	1,521.00	1,755.00	2,808.00	3,276.00	17,442.00	16,726.00	5,612.00
F. Consumption of Halocarbons and SF_6	NE	NE	NE	NE	NE	NE	NE	NE			
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3. Solvent and Other Product Use											
4. Agriculture											
5. Land-Use Change and Forestry											
6. Waste											
Total (Net) PFCs Emission	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**536.00**	**1,310.00**	**2,721.00**
1.Energy											
2. Industrial Processes	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	536.00	1,310.00	2,721.00
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production											
E. Production of Halocarbons and SF_6	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Consumption of Halocarbons and SF_6	NE	NE	NE	NE	NE	NE	NE	NE	536.00	1,310.00	2,721.00
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA
3. Solvent and Other Product Use											
4. Agriculture											
5. Land-Use Change and Forestry											
6. Waste											
Total (Net) SF_6 Emission	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**61**	**99**	**114**
1.Energy											
2. Industrial Processes	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**61**	**99**	**114**
A. Mineral Products	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Chemical Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production											
E. Production of Halocarbons and SF_6	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	
F. Consumption of Halocarbons and SF_6	NE	NE	NE	NE	NE	NE	NE	NE	61	99	114
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3. Solvent and Other Product Use											
4. Agriculture											
5. Land-Use Change and Forestry											
6. Waste											

NA：(Not Applicable)，no such gas emission from that category

NE：(Not Estimated)，insufficient information or the statistical work is not completed

NO：(Not Occurring)，no emission activity from that category

IE：(Included Elsewhere)，the calculation is listed under different category

Column in gray: the estimation of that gas is not necessary for that category

Source: Environmental Protection Administration of the Executive Yuan（2001）

Table 2.12 Total Greenhouse Gases Emissions of Taiwan in 1990 – 2000 (without LUCF)

(Units: thousand metric tons of carbon dioxide equivalent)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total*
1990	132516.25	13928.67	13999.60	--	--	--	160444.52
1991	140968.32	15116.43	14886.20	--	--	--	170970.95
1992	151272.04	17575.32	14827.30	702.00	--	--	184376.66
1993	164235.44	18821.88	15190.00	1638.00	--	--	199885.32
1994	173336.51	20043.87	15543.40	1521.00	--	--	210444.78
1995	179410.03	17995.95	15500.00	1755.00	--	--	214660.98
1996	189556.52	18292.68	15927.80	2808.00	--	--	226585.00
1997	203435.67	19193.58	14064.70	3276.00	--	--	239969.95
1998	216086.44	19312.44	13649.30	17442.00	536.00	61.38	267087.56
1999	218131.70	20160.21	13528.40	16726.00	1310.00	98.91	269955.22
2000	238935.97	12499.20	11739.70	5612.00	2721.00	114.37	271622.24

Source: Environmental Protection Administration of the Executive Yuan（2001）

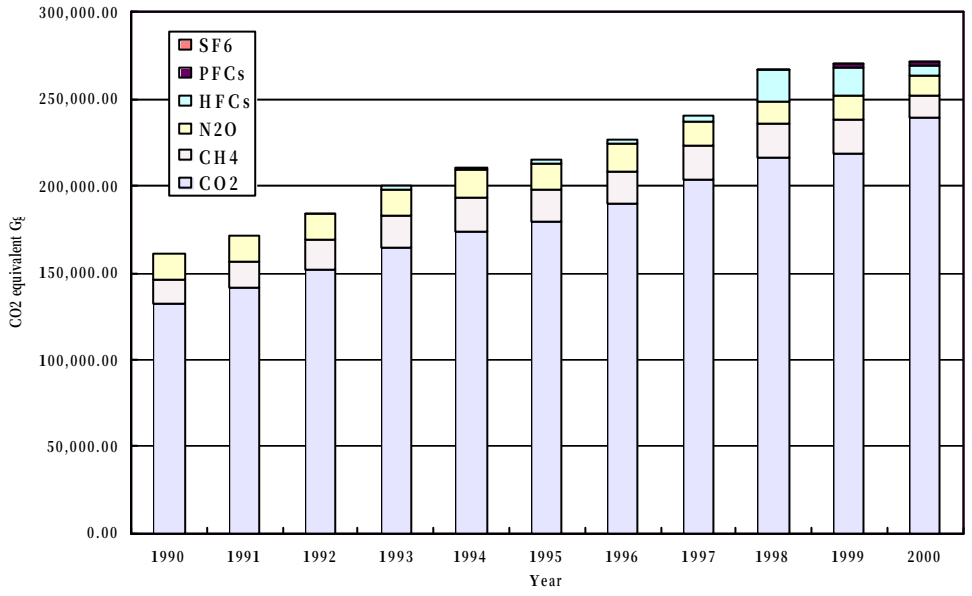


Figure 2.8 Trend in the Total Greenhouse Gases Emissions of Taiwan in 1990 – 2000 (without LUCF)

Source: Environmental Protection Administration of the Executive Yuan（2001）

Table 2.13 Total Greenhouse Gases Emissions of Taiwan by Main Sectors in 1990 – 2000 (without LUCF)

(Units: thousand metric tons of carbon dioxide equivalent)

	Energy	Industrial Processes	Agriculture	Waste	Total
1990	123108.11	11734.92	15398.25	10203.03	160444.52
1991	132724.91	10666.01	16387.37	11191.61	170970.95
1992	140630.58	13921.11	16189.27	13635.49	184376.66
1993	151683.07	16924.09	16497.38	14779.52	199885.32
1994	161577.35	16186.72	16783.23	15897.27	210444.78
1995	168244.34	16088.52	16728.98	13598.93	214660.98
1996	178506.50	17148.69	17124.71	13801.95	226585.00
1997	191938.99	18438.68	14865.80	14726.48	239969.95
1998	206911.60	31201.40	14194.21	14780.14	267087.56
1999	210318.40	30051.61	14107.50	15477.50	269955.22
2000	232947.26	17741.88	12196.02	8737.08	271622.24

Source: Environmental Protection Administration of the Executive Yuan（2001）

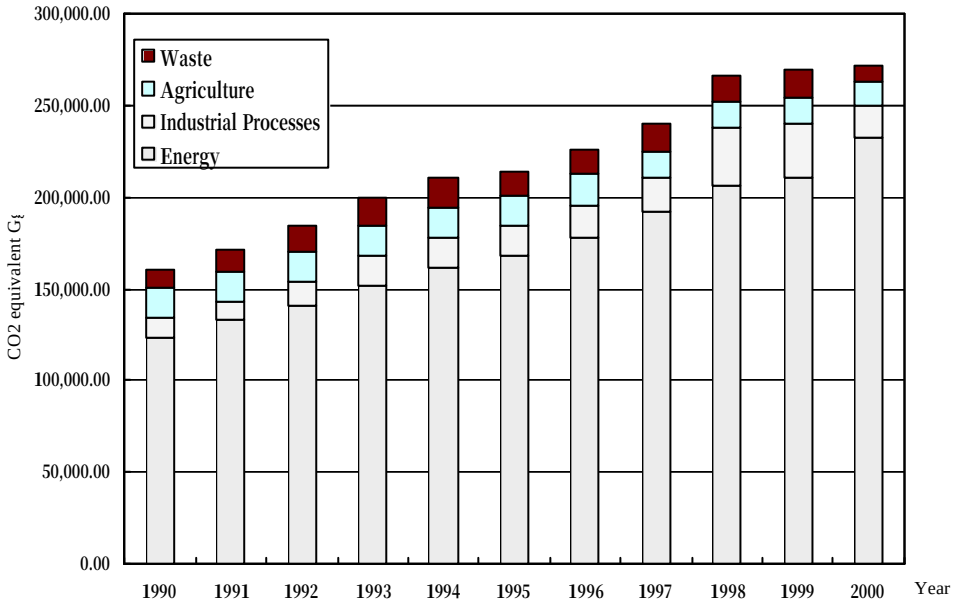


Figure 2.9 Trend in Total Greenhouse Gases Emissions of Taiwan by Main Sectors in 1990 – 2000 (without LUCF)

Source: Environmental Protection Administration of the Executive Yuan（2001）

REFERENCES

1. Environmental Protection Administration of the Executive Yuan, 2001, *Symposium on National Greenhouse Gas Emission Inventory*, 15 – 16 February 2001, Taipei.
2. Ministry of Economic Affairs, 1998, *Information on National Energy Conference.*
3. Energy Commission of the Ministry of Economic Affairs, 2000, *Energy Policy Simulation in Adaptation to the Climate Change Accord and the Energy Supply and Demand Prediction Study*, Final Report.
4. Environmental Protection Administration of the Executive Yuan, 2000, *A Study on the Greenhouse Gas Emission Estimation on Industrial Process, Usage of Solvent and Other Products,* Final Report, 2000.
5. Environmental Protection Administration of the Executive Yuan, 2000, *An Estimation of Greenhouse Gas Emission from Solid Waste and Waste Water in Taiwan Area*, Final Report, 2000.
6. Environmental Protection Administration of the Executive Yuan, 2000, *An Estimation of Greenhouse Gas Emission from Agriculture and Livestock Industry in Taiwan Area,* Final Report, 2000.
7. Environmental Protection Administration of the Executive Yuan, 2000, *Establishment and Application of an Absorption Model on Forest Ecological System,* Final Report, 2001.
8. I.P. Wang and H.W. Hsieh 1995, *Methane Gas Emission and the Influence Factors from the Soils of Water Fields in Central and Southern Taiwan, Report of the Special Topic Research Projects of the National Science Council*, Department of Soil Environmental Science, National Chung Hsing University.
9. S.L. Wang, C.T. Chen, T.M. Chang and S.C. Lu 1995, *Study on Methane Emission from Rivers, Lakes, Shallow Seas and Wetlands in Southern Taiwan,* Report of the Special Topic Research Projects of the National Science Council.
10. C.T. Chen 1996, *Mechanism and Prediction of Greenhouse Effects – Integrated Project on Adaptation to the Climate Change Accord (3) An Estimation of Carbon Dioxide Absorption in the Inner Seas of the Special Economic Sea in Taiwan,* Environmental Protection Administration of the Executive Yuan.
11. R.T. Yang and D.C. Yu 1999, *Statistics on Energy Related Greenhouse Gas Emission in Taiwan,* Energy Commission of the Ministry of Economic Affairs.
12. S.S. Yang 1996, *Mechanism and Prediction of Greenhouse Effects – Integrated Project on Adaptation to the Climate Change Accord (2) An Estimation of Carbon Dioxide Absorption by the Forests in Taiwan and the Difference between the IPCC Estimation and the Greenhouse Gas Methane and Nitrous Oxide Emission in Taiwan,* Environmental

Protection Administration of the Executive Yuan

13. IPCC, 1994a，IPCC Guidelines for National Greenhouse Gas Inventories. Vol. 1,2 and 3, November, 1994.
14. IPCC, 1996, Revised IPCC Guidelines for National Greenhouse Gas Inventories, 1996
15. PCC, 2000, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 2000
16. UNFCCC, 2000, FCCC/CP/1999/7, Review of The Implementation of Commitments and of Other Provisions of The Convention – UNFCCC guidelines on reporting and review.
17. UNFCCC, 2000, Reporting Manual – Software Application for submitting greenhouse gas inventory data in the common reporting format.
18. IPCC, 1998, Greenhouse Gas Inventory Software for the Workbook – Instruction Manual.

Chapter Three: Impacts

With the natural environment of a subtropical island, Taiwan is very vulnerable to the impacts of climate change. In particular, the impacts would include sea-level rise, lack of water resources, primary industries, public health, ecosystems, etc. The direct impacts of sea-level rise would be the flooding of coastal lands, coastal erosion, and retreat of coastal front. Coastal communities would face the problems of relocation and subsequent social adaptation. The impacts on water resources would include the increase in frequency and extent of droughts, lack of water resources, and impacts on people's livelihood and industrial development. On the other hand, the increase in CO_2 concentration would enhance photosynthesis of plants and promote forest and agricultural growth. However, it would also promote the growth of pests and propagation of disease vectors.

3.1 Sea-level Rise

1. Damages from sea-level rise

Sea-level rise will affect land use in coastal areas of Taiwan, including agriculture, livestock farming, forestry, salt pan, aquatic farming, mining, tourism, commercial and fishing ports, residence, cementery, industrial areas, nuclear and thermal power plants, airports, coastal transportation facilities, ecological protection areas, drainage and tide-defense facilities, oil and natural gas exploration, etc. The economic impacts of sea-level rise will mainly come from the loss from societal costs, including:

(1) Direct loss of land and capital from the retreat of coastal line and tidal surges ;

(2) Costs of all protection, mitigation and response measures to reduce the loss described above; and

(3) Loss of construction and development opportunities from sea-level rise. In addition, sea-level rise will increase flooding and seawater intrusion, thus worsening damages to coastal areas. It will also destroy existing fish farms, salt pans, and wetlands, affecting people' s livelihood and coastal ecosystems.

2. Related Research

Regarding the impacts of sea-level rise on the Taiwan region, flooding scenarios of

the Tsang-Wan River delta and the I-Lan sedimentary plain were modeled for rising levels of 0.5, 1, and 1.5 meters. The results show that flooded areas in the An-Ping district of Tainan City could reach 30.6%, 50.0%, and 72.5%, respectively, and in the Wu-Jiage area of I-Lan the flooded areas could reach 13.0%, 27.2%, and 40.2%, respectively. In addition, using the Chia-Nan plains as a case study, with sea level rises of 1, 2, 3 and 4 meters, the flooded coastal area of Tainan could reach 119.1, 162.7, 207.4 and 253.1 km^2, respectively. The flooded coastal areas in Chiayi could reach 51.9, 75.8, 99.8, and 121.4 km^2, respectively. Of the lands that could be flooded in Tainan and Chiayi, most are aquatic farms, salt pans and cultivated lands. In addition to the potential one-meter rise in sea level over a hundred years, effects of subsidence in Taiwan make the problem even more serious. According to investigation by the Water Resources Bureau, the rate of subsidence in coastal areas of Tainan and Chiayi is over 1 cm per year. The combined effect with sea-level rise would be over 1.5 cm per year.

Based on the results of long-term analysis of 14 tide monitoring stations in Taiwan, during the past 90 years, sea levels in Keelung and Kaohsiung showed an increasing trend, at a rate of 0.035 cm and 0.061 cm per year, respectively. However, sea level at Taichung Port has decreased 0.364 cm per year. Overall, data from the tidal stations indicate that sea levels in parts of northeast, northwest, and south have an increasing trend; sea levels in central Taiwan have an decreasing trend.

An analysis of long-term changes in coastal lines of Taiwan shows that coastal lines in the north currently remains stable overall, but erosion is more serious in some parts. In the past 20 years, coastlines in the southeast have retreated by 20-50 meters. Furthermore, coasts in central and southern Taiwan showing signs of erosion in recent years and changes as the area decreases.

3.2 Water Resources

Based on data analysis of average annual rainfall in Taiwan between 1953 and1990, the amount of annual rainfall in northern and eastern Taiwan showed an increasing trend, while it showed a decreasing trend in central and southern parts. The number of days of no rain in southern part also has an increasing trend. It was estimated by the Water Resource Bureau in 1995 that the amount of runoff rainfall in Taiwan would decrease in 4% by 2050, and possibly by 4.1% during the driest year.

Rainfall in Taiwan mainly comes from plum rains and typhoons, of which the amount of rainfall during typhoon season accounts for the most. An analysis of rainfall amount in Taiwan during typhoon seasons in 1994 shows that the percentage of annual total rainfall from typhoon decreased from southern to northern parts of Taiwan: over 50% in the southern region, over 40% in the central region, and about 30% in the northern region. Thus, the amount of rainfall

during typhoon seasons has significant effects on the water resources in Taiwan.

According to the results of a simulation of river flow changes by using the WatBal and WLF models in 1997, the river flow will increase during plentiful water period and decrease during drought period, thus intensifying flooding and drought conditions and making disaster prevention even more difficult. In terms of water resources management, it could create problems of inadequate allocation and the need to develop larger storage volumes, etc.

3.3 Industries

1. Agriculture

In terms of agricultural products, according to a 1995 study in Taiwan, a doubling of CO_2 concentrations would affect cucumber, rice and other crops. Furthermore, with changes in rainfall and distribution as a result of temperature rise, corn production could decrease by 10-20% and wheat by 7-8%. Although global warming could increase growing season and crop production, an increase in energy costs as a result of global energy control measures would directly affect crop production in Taiwan. The study shows that crop areas for sugar cane, corn, rice, and sorghum would decrease significantly, while those for tea crops would increase. The overall, crop area in Taiwan would show a decreasing trend.

2. Fisheries

Weather in Taiwan changes with the El Niño phenomenon, and the Japan Current and other minor and mainland coastal currents also change accordingly, causing fisheries production to vary widely. Eleven months after the start of the El Niño phenomenon, surface water temperature in the southern sea of Taiwan increased by 0.5℃-2℃, and the production of young fish of the *Engralididae* family dropped by over a half. The primary fish catch of Japanese enchovy (*Encraulis joponica*) was replaced by other types of enchovy (*Encracicholina heteroba* and *E punctifer*). In addition, eel fingerlings (*Anguilla jopnica*) spawn in the western part of the Mariana Islands in the Pacific Ocean, drift to the east and north with the northern equator current after hatching, and the continental shelf close to Taiwan becomes an eel corridor. In 1997, productivity in the eel corridor reduced significantly because of weakened El Niño but recovered again in 1998. On the other hand, mullets travel south every year along the mainland coast to the southwest coast of Taiwan to spawn during midwinter, consisting of an important fishery in Taiwan. As a result of climate change, if the warm water brought by the Japanese Current prevents the southward flow along the mainland coast, mullets would not be able to travel south to spawn and decrease in production. In 1998, the catch of 160,000 mullets was much less than the annual average of 1.5 to 3 million. This is a result of the continuing warming of water temperature around Taiwan, preventing mullets to travel south to spawn and even

causing migration to northern Taiwan for spawning. In addition, Taiwan has the second largest tuna industry in the world. The occurrences of El Niño/La Niña have impacts on the tuna fishing grounds and catch in the western Pacific Ocean. During El Niño, ocean temperature in tropical western Pacific Ocean decreased, causing tuna fishing grounds in Taiwan to move about 5,600 kilometers eastward and resulting in lower production. During La Niña, tuna fishing grounds concentrated toward western Pacific Ocean and resulted in increased production. Tuna production in Taiwan increased significantly in 1999, causing fish price to drop.

3. Aquaculture

Direct impacts of sea-level rise on aquaculture include clam farms located in inter-tidal area and sea-eroded platform. Their production grounds and acreage could be impacted, and there could be changes in their growth, maturity, and spawning ecology, with changes in spawning period and shortening of growth period. Indirect impacts are harder to predict. Coastal subsidence due to overuse of groundwater would intensify the effect of sea-level rise on nearby coast. There's clear impact of water temperature on fish and marine ecosystem, including physiology, metabolism, behavior and distribution of fish. An increase of 10℃ in water temperature could increase biochemical reaction in fish by 6-10 folds; if the temperature changes by 2℃, it could change the reproductive season of fish, and higher temperature could cause fish to spawn early. If future climate change moves the warm belt north, it could also change the geographical distribution of fish species in Taiwan.

4. Livestock Production

Livestock industry in Taiwan consists mainly of pig and poultry, with cattle as secondary. For pigs, if the temperature rises one degree above their optimum growth temperature, feed intake would decrease by 5%, and activity would decrease by 7.5%. Livestock growth and reproductive ability and temperature are closely related. When the temperature increases to 27℃, the estrus cycle of milk cows would be prolonged, estrus signs weakened, estrus period shortened, the gestation rate would decrease, and fetal death rate would increase. Another study confirmed that in Taiwan the conception rate of milk cow and temperature are closely related. For poultry, with increasing temperature, its maturity delays, and its body weight, laying rate, egg weight, protein quality, and feed intake all decrease. This would result in increasing nitrogen and phosphorous content in feces.

5. Macroeconomic

A 1996 study by Mendelsohn used the scenario of 2.5℃ rise in temperature, 8% increase in average rainfall, atmospheric CO_2 concentration of 550ppm, and sea-level rise of 44 cm to assess the impacts of climate change on 20 countries in the Pacific region,

including Taiwan. The loss from the impacts was estimated to be USD 37 billion per year. The impacts included market and non-market categories: market category covered agriculture, coast, energy, forestry and tourism, and non-market category covered aesthetics, ecosystem and health. The study found that the impacts of climate change on the market is smaller, averaging about 0.1% of the GDP. The larger effects of climate change are non-market impacts, but the level of impact is highly uncertain. For developed countries, the impacts may be within tolerable range, but for developing countries, the loss from impacts could consist of a high percentage of the GDP. According to estimates by Mendelsohn, the loss for Taiwan could reach USD 1.3 billion per year, about 0.6% of the GDP.

3.4 Public Health

The rise in the earth's surface temperature as a result of climate change from the greenhouse effect has various impacts for different regions. In terms of public health, the negative impacts are larger for tropical and coastal areas. Deficient water resources as a result of warming or variation of climate could lead to relocation of residents, and such relocation could spread infectious diseases and cause an indirect impact on public health. The degree of indirect impacts by no means is less than that of direct impacts. Therefore, when considering the impacts of climate change on public health, both direct and indirect impacts should be included. Furthermore, some regional environmental pollution and destruction, such as suspended particles, loss of topsoil, subsidence and algal growth, usually would have incremental effects when combined with the impacts of climate change.

Warming of the climate could increase concentrations of environmental allergens (such as fungus and pollen), thus increasing the prevalence and seriousness of asthma and hay fever sufferers. The portion of children with asthma in Taiwan has increased from 1.3% in 1974 to 5.08% in 1985, 5.8% in 1991, and 10.79% in 1994. Room dust and fungus are found to be the main allergens. A study shows that about 45% of children with asthma in the city of Taipei are allergic to fungus. Climate change could affect the growth of room dust and fungus and indirectly lead to the occurrence of allergic illnesses. In addition, a 1995 study found that climate warming could cause six species of rodents carrying Hantavirus to proliferate in Taiwan and thus increase the potential of the disease agents.

In central and southern Taiwan, dengue fever has usually occurred during summer and autumn. As a result of climate change, now it has spread to the northern area, and the occurrence period has lengthened; some cases have even occurred in December. Such phenomena could worsen with the increased growth of disease-carrying mosquito caused by warmer temperatures. According to statistics, in 1988 dengue fever occurrence in Taiwan peaked in October, decreased in November, and ended by December. In 1991, domestic cases of dengue fever concentrated between September and October, decreased in November and ended by December.

Due to warming climate in 1994-1995, four cases were found in southern Taiwan in December 1995, and by 1998, the occurrence extended until January 1999. Based on the trend of warming climate, the threat of year-round occurrence of dengue fever could happen in Taiwan.

According to a 1998 study, climate change has direct as well as indirect impacts on public health. The increase in death rate from temperature rise is a direct impact, whereas the proliferation of disease vectors causing the spread of diseases an indirect impact. The potential direct impacts of global warming and climate change on human health include heat stroke and heat exhaustion, and the indirect impacts are changing the ecology of disease vectors that endanger human health.

3.5 Ecological Systems

1. Forest

Due to influences by climate, soil, terrain and biogeographical location, terrestrial ecosystems in Taiwan are mainly based on forests. The complex island environments have formed different types of forests adapting to long-term environmental conditions, especially the rainfall and temperature characteristics of the climate. If global climate change occurred by unnatural causes, it could have various levels of impacts on the condition and processes of forest ecosystems, resulting in lower productivity and loss of bio-diversity and also indirectly affecting its services to human. For example, natural forests in high altitudes could decline because of inability to adapt, and species in medium altitudes (especially plant composition) could lose diversity.

According to the third survey of "Forest Resources and Land-use in Taiwan" completed by the Forestry Bureau in 1995, forest cover area in Taiwan is about 2.1 million hectares, occupying 58.5% of total land area. With the special geographical condition and fragile geology of Taiwan, combined with frequent natural disasters, a well-maintained, extensive forest is needed to protect developments in the plain region. On the other hand, with rapid economic development, there are increasing demands for forest products and forest recreation in Taiwan. Since over 99% of domestic timber demand rely on imports, quick strategies are needed to increase self-sufficiency in domestic timber production. In addition, the richness and diversity of biological resources in forests have valuable potentials and still require further research. Therefore, adjusting to developments in forestry management and environmental conservation worldwide, appropriate revision of forest resource management in Taiwan is an importance part of our modernization.

2. Marine Ecology

Climate change will affect ocean temperature and circulation, thus impacting the ecology of fish and other marine organisms. A 1995 study in Taiwan shows that water

temperature could affect the physiology, metabolism, behavior, and distribution of fish. If water temperature increases by 10℃, biochemical reaction in fish could increase by 6-10 folds. If the temperature change by 1-2℃, it could change the reproductive season of fish, usually with lower temperature causing fish to spawn late and higher temperature causing fish to spawn early.

Chapter Four: Adaptations

To address the impacts of climate changes on Taiwan, in addition to related studies on greenhouse gases, adaptation strategies are being considered to lessen the level of impacts from climate change. Long-term strategies for adapting to climate change (e.g., standards for flood prevention designs) should be reviewed immediately. As for the short-term (e.g., management and allocation), flexibility should be added with the changing environment, giving gradual revisions. Considering the results of related studies and policies, the relevant government agencies have devised the following adaptation strategies:

4.1 Sea-level Rise

Like other island countries, Taiwan will increasingly face serious coastal erosion. The following adaptation strategies will be taken:

1. Complete impact assessment of sea-level rise in the entire Taiwan region: delimit potentially flooded areas, affected population, and socioeconomic impacts, according to local terrain, nearby industries, population and culture, for strategy and prevention reference.
2. Coastal zone protection and establishing new tidal prevention and drainage system: establish and draw up new design standards for coastal embankment, tide and flood prevention, and drainage systems, and draft new prevention methods and carry out flood modeling analysis in order to respond to future conditions to protect life and property in coastal regions.
3. Reducing impacts from sea-level rise: land-use restriction in coastal areas, control of building in low-lying areas, industry transformation assistance, wetland protection, flood protection, and sand dune protection.
4. Preservation of coastal wetlands and ecosystems: using transplantation, coffer dam or other artificial means to protect rare coastal ecosystems.
5. Control of large-scale coastal developments: re-evaluate plans for coastal industrial parks and integrate sea-level rise as an element of environmental assessment of large coastal projects.
6. Obtaining experiences from international cooperation: actively participate in

international cooperation projects.

7. Transitional assistance and planning for non-recoverable industries: for flooded areas not able to be recovered by preventive strategies, assist residents in relocation and job change, in order to minimize socioeconomic impacts.
8. Defining flood plain areas and implementation of flood insurance systems: establish different levels of flood areas, prevent reckless development, and implement flood insurance system.
9. Establishing monitoring systems: including sea-level monitoring system, coast and coastal structure monitoring system, expand subsidence monitoring system, and enhance establishment of coastal database.

4.2 Water Resources

In order to reduce the level of impacts of climate change on water resources in Taiwan, suitable adaptation strategies consist of three major areas: water resource conservation, development, use and management; strengthening flood control and rescue; and drought prevention and emergency response.

1. Water resource conservation, development, use and management
   (1) Development of surface water as primary, given consideration to the base flow of river ecology, and development of groundwater as supplementary, with increased development of other water resources.
   (2) Actively developing and overall allocating water resources.
   (3) Establishing management of water rights and collecting water right tariffs, and developing the standard for water measurement equipment in order to put into practice the user-pay principle.
   (4) Strengthening water utilization management, raising water utilization efficiency, and overall allocation of waster resource.
   (5) Reinforcing the management and conservation of watersheds, conservation of water sources, and maintaining natural ecological function of water systems.
   (6) Promoting modernization of hydrological monitoring, developing groundwater observation network, and establishing the principles for groundwater use and protection.
   (7) Promoting research and development of water resource technologies in order to meet the technological needs for water supply, water conservation, diversion dam, flood control, coastal protection, groundwater conservation, and subsidence prevention.

2. Strengthening flood prevention and rescue

(1) Construction of flood prevention structures: conduct river and sea embankment and regional drainage projects.

(2) Strengthening maintenance management: reinforce river management plans, establish safety inspection system for water structures, integrated protection plans for small and medium dams.

(3) Establishment of disaster prevention and response mechanism.

(4) Research in disaster prevention technology: focussing research on flood prevention and rescue database, typhoon disaster potential analysis, and flood forecast network.

(5) Non-engineering flood control measures: strengthening review of land-use planning for flood plains, promoting flood insurance system, and establishing flood warning system.

(6) Integrated flood control measures for reservoirs: strengthening water conservation, increasing surface permeation, decrease flood peak flow, and considering ecological protection and environmental landscape.

3. Drought prevention and emergency response

(1) Establishing drought prevention and response systems

(2) Promoting related work on prevention and response: enhance reservoir protection and groundwater control and monitoring, research water conservation technologies for industries, develop alternative water resource technologies, develop new water resources, protect water quality, regularly publish water supply and demand conditions, and promote education on water resource protection and conservation. Special emergency response measures for droughts include: regularly publish drought information, stop fallow irrigation, and make artificial rain.

(3) Devising future development goals and response measures: establish central to local drought prevention and relief system, strengthen research on drought warning system, promote education on water resource and watershed protection, and review coordination problems among existing policies and regulations.

4.3 Industries

The most direct impacts of climate change on Taiwan's industries include agriculture, fisheries, and others. The adaptation strategies are described as follows.

1. Adaptation strategies for agriculture and livestock industries include:

(1) Depiction of weather pattern as a result of climate change; planning and protection of

agricultural production regions.

(2) Promoting rational fertilization methods and the use of slow-rate fertilizer.

(3) Nurturing growth of species adaptive to new environments.

(4) Early prevention of possible new plant diseases and weeds.

(5) Drafting response measures to agriculture and livestock production affected by disastrous weather and new climate.

(6) Improving animal housing and feeding management, as well as research on technology of processing animal excrements.

2. Adaptation strategies for fisheries include:

(1) Drafting response measures to agriculture and livestock production affected by disastrous weather and new climate.

(2) Collect and analyze the amount of emissions from fishing boats, in order to promote emissions control and incentives for fishing boats to install energy efficient motors in compliance with environmental standards. At the same time, buy back old fishing boats and implement boat reduction strategy.

(3) Study the effects of climate change on the ecology of migratory fish and establish database for international use.

(4) Analyze the impacts of climate change on fisheries to adopt measures to assist the industry.

(5) Provide assistance in the use of sea cages for cultivation in order to reduce the area of inland fish ponds, reduce reliance on water and land resources, and mitigate subsidence.

4.4 Public Health

Climate change could increase the growth, distribution and density of disease vectors. In order to prevent the interminable aftermath, adaptation strategies to control diseases should be drafted early. The strategies should include:

1. Comprehensive survey of all types of disease vectors and monitoring their density and growth in all regions, in order to understand the results of climate change and the temporal and spatial distribution of disease vectors.
2. Strengthening quarantine, case reporting, and examination of pathogens. Enhancing study on distribution of disease vectors in order to provide measures for disease prevention and control.
3. Timely publication of the monitoring results of disease vector densities in order to

provide warnings to public health officials, physicians and the public, to eliminate disease vectors early and prevent cross-border introduction of pathogens.

4. Early detection of cross-border disease cases and infections without symptoms, to block invasion of pathogens that could lead to disease outbreaks.
5. Strengthening hygiene education and environmental hygiene improvement in order to diminish propagation of disease vectors.
6. Establishment of investigative teams at all levels of government to conduct unscheduled inspections and publicize the results in order to encourage the public to voluntarily eliminate sources of disease vectors.
7. Promoting international exchange of information and control technology of disease vectors.

4.5 Ecological Systems

Forest is the largest ecosystem in Taiwan and has the greatest impact on the overall ecosystem. Future adaptation strategies for forest ecosystem include:

1. Administrative and managerial organizations of national forests would establish teams to implement management plans for forest ecosystems, with watershed or forest region as management units, planning according to land capacity within management area, and developing sustainable management systems based on ecology.

2. Establish mixed forest to increase biological diversity of species, accommodate species at the early stages of succession, and maintain adequate amount of dead standing and fell tree in the forests, increase biological diversity at the ecosystem level, and maintain normal flux and elemental cycles of ecosystems.

3. Establish permanent plots for forests island-wide and long-term ecological monitoring stations in order to obtain continuous data on landscape, forest distribution and growth.

4. Give adequate adjustment to the way forest areas are divided, establish forest land classification system, area management according to different management goals, and ensure sustainable development of forest ecosystems.

5. Strengthen conservation of ecosystems along the banks of streams, reservoirs and other water bodies in the forest area and management aquatic ecosystems in order to ensure biological diversity.

6. Preserve forest productivity functions by delimiting at least 400,000 hectares for sustainable forestry management.

7. Establish channels for public participation in forest management policy and solicit public opinions and approval from various types of landowners in order to integrate societal needs into national forest programs.

Furthermore, research would be conducted in fields related to climate change, and regional climate monitoring, assessment and modeling would be enhanced in coordination with relevant researchers. Such can be advanced by adaptation strategies to climate change, thus minimizing the level of impacts.

In the future, more emphasis should be placed on integrated research, such as the impact of forest type change on flow rate, impact of agricultural water use on water resource allocation and adaptation measures. The research should be advanced following the path of international research.

Chapter Five: Policies and Measures

5.1 Taiwan's Perceptive Position

Because Taiwan is not a member state of the United Nations, she is not eligible to ratify the United Nations Framework Convention on Climate Change (UNFCCC). However, as a member of the global village fulfilling the responsibility of protecting the worldwide environments as well as attaining sustainable development, Taiwan would still respond actively and push forward different policies of no regrets. This is in accordance with the spirit of the UNFCCC on climate change as "common responsibility but to different degree", and "cost effective" as well as "lowest cost" procedures.

In addition, the government will still actively partake in the conference of parties of UNFCCC and the relative working group meetings. Through some bilateral consultative courses as well as Asia-Pacific Economic Cooperative (APEC) meetings, Taiwan's efforts on reducing the emission of greenhouse gases could be understood by the international community, and the recognition and support of our government could be achieved.

5.2 Taiwan's Policy

In response to UNFCCC, the government of Taiwan has deployed different policies to be executed by the energy, industrial, agricultural, forestry and waste (and wastewater) sectors, in which the 'no regret' energy policy is being put as the top priority. The related perceptive policies are:

1. Energy Policy and Energy Structure Adjustment:

   Promoting energy conservation, elevating energy efficiency, researching new energy technologies and developing clean energy.

2. Industrial Policy and Industry Structure Adjustment

   Promoting balanced development on industry structure, volunteering energy conservation by the industry, clean production, environmental management, and green products.

3. Agricultural Developmental Policy

   Promoting administration of sustainable agriculture, maintenance of ecological balance, and rational dispensation of agricultural land to other sectors.

4. Forestry Administration Policy

   Promoting sustainable administration, multi-objective utilization on resources, and expansion of forest area.

5. Waste (Wastewater) Prevention Policy

   Enforcement on control of pollution sources, clean production, and waste-to-energy.

5.3 Perceptive Measures

According to the policy stated by the respective ministries of the Executive Yuan, the abatement measures set by the energy, industrial processes, solvent and other product use, agriculture, land change and forestry, and waste sectors which are the main greenhouse gas emission sources are as follows:

5.3.1 Energy Sector

1. Promotion of energy conservation and elevation of energy efficiency

   On promoting energy conservation measure in the energy conversion sector, industry, transport as well as residential and commercial sectors, it is estimated that the accumulated energy conserved would be 16% by 2010, and up to 28% by 2020. The accumulated amount of energy saved would be 19.73 billion kiloliters of oil equivalent in 2010 and 41.87 billion kiloliters of oil equivalent by 2020.

   (1) Energy Conversion Sector

   The objective of the energy policy in the Taiwan area is to establish a free yet with order, efficient and clean energy supply and demand system. The system should be based on the ideology that is feasible in the present situation, as well as with local distinctiveness, unexploded frontier attributes, public acceptability and practicality. Further, in accelerating the liberalization and privatization of the energy business, a comprehensive energy policy system balancing energy, environments and economy should be established.

   As of the two major division of the energy conversion sector, the electric and petroleum business divisions, they are working hard on reducing the emissions of greenhouse gases. The typical measures are:

   a. Electric business division

   (a) Raising thermal efficiency of electric generators of power plants

The primary goals are to raise the thermal efficiency of the newly installed power generators, maintain the thermal efficiency of the existing power generators, and establish thermal efficiency standards of the electric generators of different types of thermal power plants. Further, in raising the efficiency of the transmission and distribution so that losses on transmitting electricity through the power lines can be reduced. Secondly, the power factor is being raised through improvement of grid structure, control of fault electricity and reduction of voltage instability rate, as well as careful planning of the use of capacitors.

(b) Continue executing the promotion of co-generation and encourage construction of natural gas-fired power plants as well as the use of renewable energy

Until April 2001, the total capacity of co-generation power plants in Taiwan is 4,820 MW. It is expected that with the growth rate of 200 MW per year, the total capacity will reach 5,500 MW by the year 2005. In addition, in privatizing power plants and on using natural gas as fuel, the ratio on using natural gas in power generation of the whole system will reach 35 % by 2007. Further, on promoting the use of renewable energy, "Research and Development Planning Group on the Use of New and Clean Energy" was established inviting academics and experts in Taiwan. The group will study the development potentials so that accurate and feasible plans could be made that the goal of 3 % of the total energy supply to be provided by the use of renewable energy by 2020 could be reached.

(c) Aggressive promotion of Power Demand Side Management (DSM)

On the load management and energy conservation procedures practiced at present, the load management reduced 170 MW of peak power each year on the average for the past 5 years. It is estimated for the coming 5 years, 120 MW of power demand will be reduced each year. Further, through dissemination on the energy conservation procedures, 50 MW of electricity could be reduced each year. In the future, a comprehensive planning study should be carried out on the power demand side management system that the groundwork and structure of power demand side management system of Taiwan could be carefully established, and the planning of total energy conservation procedures could be complimented. Moreover, the energy saving mechanism of the power market of Taiwan could be built, the rational management of electricity market is promoted, the peak power load is further cut, the stress on building new power plant is reduced to reach the goal on reduction of the emission of greenhouse gases.

b. Petroleum business division

The liberalization and privatization of petroleum business division will continue to be promoted. In the first stage starting January 1999, fuel oil, jet fuel and liquefied

petroleum gas are opened to import. In the second stage, starting from December 26, 2001 complete line of oil products had been opened to import. The "Petroleum Administration Law" was promulgated on October 11, 2001. This will be the guideline on managing the petroleum market. The privatization of the Chinese Petroleum Corporation is expected to be completed by 2003. Energy conservation is the main policy of the Chinese Petroleum Corporation. At present, "Procedures on Energy Conservation of the Chinese Petroleum Corporation" has been set to elevate the efficiency of energy management and to reduce the waste on energy utilization.

c. Assertively promoting the use of natural gas

The natural gas utilization has been increased from 3.48 million metric tons in 1997 to 13 million metric tons in 2010 and 16 million tons in 2020.

d. Establishment of future energy structure and power structure ratio

The energy structure in 2020 is planned to be 27 to 30 % of coal, 37 to 40 % of oil, 14 to 16 % of natural gas, 1 to 3 % of hydroelectric, 13 to 15 % of nuclear power and 1 to 3 % of new energy.

e. Promotion of the policy on the use of low sulfur oil

The sulfur content of all kinds of oil product will be further reduced.

(2) Industrial Sector

Energy used in the industrial sector in 2000 was 48.5 % of the total energy consumption. The energy used by the energy intensive industries (including steel, petrochemical, cement, paper making and manmade fiber industries) was 65.5 % of the energy used by the industrial sector. Hence, the most effective method to reduce the emission of carbon dioxide gas is to adjust the industry development policy. The newly developed industry with high added value and less energy consumption as well as high industry related effects will be encouraged. In addition, advancement of the traditional industries in Taiwan as well as raising the added value with the use of high technology will also be encouraged. The related perceptive measures on the abatement of emission of carbon dioxide are as follows:

a. Comprehensive balanced development will be emphasized on future adjustment of industrial structure

The industrial structure in 2020 is planned to be 55 % of the gross domestic products to be technology intensive industry, 20 % to be traditional industry and 25 % to be primary industry.

b. Establishment of energy efficiency index of new plants

The energy efficiency index of the main products of the newly introduced energy intensive industry will be developed in different stages. The applicable technology of high efficiency will be brought in and admission procedure of examining the energy efficiency of the new plants will be established. It is expected that an accumulated amount of 4.37 million kiloliters of oil equivalent of energy will be conserved by 2020.

c. Implementation of energy audit system

The energy efficiency of the top 100 energy intensive business in Taiwan will be audited. Business with comparatively low energy efficiency will be requested to improve their performance on schedule. At the same time, energy intensive business will be assisted on establishing goals of energy conservation and executing the related projects. It is expected by 2020, the energy utilization efficiency of the industry will be elevated with an accumulated amount of 4.45 million kiloliters of oil equivalent of energy.

d. Promotion of projects on voluntary energy conservation by industry

The steel, petrochemical, cement, paper making and manmade fiber industries will be assisted to set up projects on promotion of energy conservation. Energy efficiency will be elevated and production cost will be reduced. It is expected an accumulated amount of 1.9 million kiloliters of oil equivalent of energy will be conserved by 2020. The energy utilization of different plants, the energy efficiency, the structure of data bank and periodic data on the emission of carbon dioxide of the 5 major industries were completed by June 1999.

e. Elevation of energy efficiency standard on industrial equipment

The standards on energy consumption efficiency of electric motors, boilers, industrial refrigerators and air conditioners equipment are raised, and the assessment as well as implementation system is established. The amendment completed in December 1999 raises more than 5 % on the national standard of the efficiency of 3-phase electric motors, and the new standard to be enforced by January 2002 would match the efficiency with that set by American and Canadian standards. The period of two years in between these two standards is for assisting the industry to improve the production technology. The new (amended) energy efficiency standard on boilers, industrial refrigerators and air conditioners will be made in 2001 and will be implemented in 2003.

f. Extending the implementation of subsidy on energy conservation

In accordance with the Statute for Upgrading Industries, the government provides corporations with incentives to procure energy-conservation equipment in

the form of a two-year accelerated depreciation scheme, a 10% to 20% tax credit, and low-interest loan.

g. Service on energy conservation technology

The government provides technical consultation, inspection, examination, assessment, planning, as well as design on energy conservation technology for small business, and assistance in improvement engineering work as well as aids in bringing in technology. Energy Service Companies (ESCOs) will be established to assist the operation efficiency and energy utilization efficiency of factory. It is expected by 2020, an accumulated amount of 2.5 million kiloliters of oil equivalent of energy could be conserved. Assistance in energy conservation technology is provided for over one hundred and more small businesses Capital raising can be assisted as well as technology is brought in. The planning of domestic market and system on energy conservation service is concluded. In accordance with the scheduled improvement work on energy audit, ESCOs industry is established.

h. Promoting international projects on concurrent reduction

In promoting projects on concurrent reduction with other nations, cooperation and transfer of technology could be enhanced between nations. This could elevate the production, energy conservation and reduction technology of the industries in Taiwan.

(3) Transportation Sector

a. Elevation and establishment of energy consumption standards for cars and motorcycles

The energy consumption standards of cars and motorcycles are amended in stages. The energy consumption standards of passenger cars (sedans or station wagons) and motorcycles will be raised 5 % to 10 % in accordance with different vehicle classes by 2003. The fuel efficiency of motorcycles could be raised 30 % and that of passenger cars 20 % by 2020. The energy consumption standard of light truck, small commercial vehicle, and passenger car (not sedans or station wagons) was set in 2001. With assertion on promotion of energy saving cars and motorcycles, it is expected an accumulated amount of 1.79 million kiloliters of oil equivalent of energy could be conserved.

b. Promoting the use of energy conserving vehicles

Promote electric scooters, research and develop critical technology, set up peripheral utilization environments and institute relative laws. Accelerate the retirement of old vehicles. Conclude developing relative technology of electric scooters by June 2003, and promote the use of electric scooters. In addition,

depending on the maturity of the alternative energy technology, promote the use of buses running on alternative energy. Promoting in stages the use of natural gas buses, hybrid buses and electric buses. It is expected that an accumulated amount of 0.83 million kiloliters of oil equivalent of energy could be conserved by 2020.

c. Develop fuel cells for electric scooters

Taiwan is capable of designing and manufacturing electric scooters. To solve the problems such as insufficient running distance between charges, "Research and Applications Project of Fuel Cells" is promoted. The following projects are being executed : establishing "Fuel Cell Promotion Group" by the Executive Yuan to set up Taiwan's development policy, assisting private industries to establish "Fuel Cell Partners Union" to develop fuel cell electric scooters, working on fuel cells development and application research projects, and working on commercialization development projects of fuel cell electric scooters.

d. Foster mass transit systems on rail

Promote the construction of high-speed railway. Construct metropolitan mass transit system. Elevate the service quality of Taiwan Railways by reaching 1.89 billion man-rides by 2020. It is expected an accumulation amount of 0.74 million kiloliters of oil equivalent of energy could be conserved by 2020. The high-speed railway is scheduled to be finished by December 2005 and the construction of Kaohsiung metropolitan mass transit system to be completed by 2017.

e. Implement management strategy on transportation system

Implement automatic ramp traffic controls and high passenger rate control policy on highways. Reduce the numbers of small passenger cars on the use of highway throughout the year. Promote the construction of computerized traffic light systems to reduce the energy consumption by moving vehicles. It is expected an accumulated amount of 0.3 million of kiloliters of oil equivalent of energy could be conserved by 2020. The automatic traffic control systems of the entire first north-south highway will be completed from 1999 to 2003. Beginning 2001, the computerized traffic system is being constructed successively.

f. Develop intelligent transportation system

Develop electronic automatic toll collection system to reduce the slowing down of vehicles and thus the waste of fuel when passing toll station. Develop priority traffic system for buses to increase the bus speed and improve management efficiency so that the passenger rate could be elevated. It is expected an accumulated amount of 1.26 million kiloliters of oil equivalent of energy could be conserved in 2020. Starting 2002, electronic automatic toll collection system is

constructed for the entire traffic system to be completed by December 2016. Beginning 2003, the practice of priority traffic system for buses will be extended.

g. Lower the environmental impacts associated by transportation activities

(a) Pursue integration of the three rails including Taiwan Railways, High-Speed Railways and Mass Rapid Transit Railways. Work on "System Integration Planning of the Rail Transit System of the Taiwan Western Corridor", including projects such as "Improvement Engineering on Outer Rail Linkage of the High Speed Railway Station Areas", "Increased Stops in the Metropolitan Areas" and "Combined Stations of the Three Rail Systems in the Metropolitan Areas". Plan on integration the land use for transportation. Reduce or redistribute the space and time associated with travels.

(b) Apply communication technologies to reduce transportation needs. On sea passages, the construction of hub stations for seaway data network is completed. On mass transportation, prudently pursue work on intelligent mass transportation system, metropolitan transportation system, inter-city transportation system as well as commercial transportation system. Plan on promoting the development of advanced transportation management system, advanced travelers data system, advanced mass transportation system, and construction of electronic toll collection system. These measures are to solve the problems on transportation so that the limited transportation resources could attain the largest achievements with highest efficiency.

(c) Reduce environmental pollution from harbors and sea transportation activities. Promote projects on energy conservation for fishing vessels and assist replacement of retired old fishing vessels to reduce the carbon dioxide emission from this source.

(d) Develop "Green Transportation" to incorporate humanization and beautified landscape. With aspects on "Value Engineering" and "Environmental Protection" to evaluate the planning and design of each engineering projects and procedures. Designs on engineering construction and landscape integration will be emphasized on any future new projects. During the engineering construction, not only the construction technology is considered but the harmony between human and nature will also be incorporated.

(4) Residential and Commercial Sector

a. Elevate the efficiency standards of electric appliances

To raise the energy efficiency standards of air conditioners, refrigerators, lucent lamps, laundry dryers and electric motors for 5 % to 25 % in stages. It is expected an accumulated amount of 3.36 million kiloliters of oil equivalent of

energy could be conserved by 2020.

b. Project on green buildings and residential environmental technology

The goal of this project is to promote co-existing and co-benefit of buildings and environments, sustained administration of living environments and to elevate the quality of living. The executive measures include:

(a) In order to enhance the benefits of energy conservation of buildings, the government passed the rules on building technology the energy consumption index of building exteriors (ENVLOAD) for regulation in 1995 and was later revised and broadened the applicable targets. It is expected that about 57 % of buildings will be put under regulation.

(b) Assist the training of instructors on energy conservation auditors. In compiling training materials suitable for domestic building energy conservation, concepts and technology on energy conservation could be disseminated through education.

(c) In conjunction with the "Prevention of Water Pollution Law", amendments on building technology regulations are studied. Regulations on the design technology on waste water treatment facilities are also installed and practiced in 1999 to uphold the quality of living environments.

(d) In reference to the classroom illumination standards of advanced countries, the Ministry of Education has revised with approval from the Executive Yuan the illumination standard of general classrooms in schools as: not lower than 350 meter-lumens for desk illumination and not lower than 500 meter-lumens for blackboard illumination in principle. In addition, attention should be made to avoid side lights from lamps to assure luminous environments for protection of the health of the eyesight of the students. Further, schools of all grades are assisted to use high efficient and energy saving lamps for conservation of energy as well as improvement on the luminescence quality.

(e) In conjunction with the energy policy of Taiwan, plans on comprehensive energy conservation and energy efficiency elevation of the residential and commercial sector was studied. It is expected the goal of energy conservation of 28 % will be reached in 2020.

c. Research and develop the 7 assessment indices on green buildings with indigenous distinctiveness

Integrate and develop green building technology. Complete researching the 7 assessment indices on green buildings with indigenous distinctiveness including: green index, ground water preservation index, water resources index, green house gas reduction index, ordinary energy conservation index, waste reduction index, as

well as waste water and refuse improvement index. These indices are set to let both the venture and consumer could have a common assessment guideline. The results will be collected and edited as a "Portrayal and Assessment Handbook of Green Buildings".

d. Realize promotion projects of green buildings

In concurrence with the goal of building a green silicon island, green buildings that preserve ecological environments are aggressively pursued. On 8 March 2001, the Executive Yuan approved the "Green Building Endorsement Project" as introduced by the Ministry of the Interior. Starting from the public buildings of the governmental departments and encouraging the participation of private sector, the market mechanism and environments of green building business will be naturally formed. The goals of effective use of resources, energy conservation as well as carbon dioxide reduction will be reached. The practical administration measures are as follows:

(a) Beginning 1 January 2002, new public buildings with total revenue of more than NT$ 50 million of the central government, or those receiving more than half of its subsidy from the central government will have to receive green building candidate certification before allowed to apply for construction permit.

(b) As regulated by the energy conservation design of building exteriors (ENVLOAD), items listed in the construction permit will be examined and submitted for audit.

(c) Plan on awards or subsidy on improvement of energy consumption of old buildings.

(d) Adapt systems on interior environmental quality assessment and green building material emblems.

(e) Investigate (revise) regulations and laws on relative technologies on construction material waste recovery and renewed utilization.

(f) Investigate (revise) relative rewarding mechanism on green buildings.

e. Sponsor activities on election of green house emblems

Co-sponsoring with mass communication media on competition activities on green house emblems. In addition to promote the concept of green buildings, extended public participation is endorsed.

f. Fortify energy consumption index on structure exteriors

Continue to execute the investigation assessment on the design regulation on energy conservation of the six kinds of buildings as set by the energy conservation

regulation. Investigate and revise the energy consumption index on building exteriors (ENVLOAD), and practice accordingly.

g. Establish valuation system on building energy conservation

Design test methods and experimental systems on building materials character evaluation to set up gradually the building materials character certification mechanism. Beginning 2003, the respective department will be inspecting construction materials, and extend the pursuance on building energy conservation policy accordingly. The energy consumption standards of construction material for building exteriors were passed in December 1999. In 2000, the "Laboratory for Measuring Thermal Congregation Rate of Building Structures" was instituted to establish analyzing methods of measuring thermal insulation character of building materials and mechanism of future evaluation procedures. Hence, results on promotion of extended energy conservation design on new buildings will be enhanced.

h. Establish total energy management system on buildings

Investigate and analyze energy consumption data of all kinds of buildings every year. Presently, the investigation and analyzes of the total energy consumption of commercial and residential buildings have been completed. The electricity consumption data of department stores, hotels, hospitals as well as other buildings will be investigated and analyzed, so that the electricity consumption standards for all kinds of buildings and respective improvement strategy can be based on. Based on the research results of investigation on electricity consumption, the preferential rate system of electricity can be assessed and be extended to the residential and commercial buildings. This is to evaluate the feasibility of effectively controlling the building that electricity can be used rationally.

i. Execute project on 'energy star' buildings

Through the Taiwan/US collaborative "Energy Star Project", respective practical technology and experiences on building energy conservation could be introduced. A commercial building will be selected from Taipei and Kaohsiung each to promote the energy efficiency improvement project on lighting, air conditioning, electrical machinery, and office utensils for the demonstration of energy conservation building promotion in Taiwan.

2. Closely monitor the development trend of UNFCCC to investigate perceptive policy of Taiwan

(1) Build analytic models of economic growth and cost on reduction of greenhouse gases to

emphasize the policy analyses as well as assessing the influence of foreign environmental policy on the economic growth of Taiwan and the cost of green house gas reduction.

(2) Revise the national communication report of Taiwan to attain international support of our volunteering action on reduction of greenhouse gases.

(3) Promote projects on joint efforts of multi-nations on reduction and investigate the trading system of quotas on emission of greenhouse gases

(4) Establish the reduction base lines for greenhouse gases.

3. Emphasize energy technology development

(1) Put together NT$ 10 billion from the Energy Funds in five years for the promotion of energy conservation, energy efficiency elevation and research and promotion of the use of clean energy.

(2) Plan and promote long term development plans on energy technology among ministries in the Executive Yuan. Taking the reference that new energy and clean energy as in the optimistic inventory potential is able to reach the goal of 10 % of the total energy allotment by 2020 (7.8 % when not counting new energy utilization and 5.2 % without additional hydroelectric power), an additional and more realistic goal of 3 % of the total energy allotment (not including new energy utilization and hydroelectric power) is planned. Policy is made and system is established for green environmental protection and sustained development. Using 3 E's, viz. Engineering, Economy and Regulation as assessment yardsticks, as well as Environment as the three factors for the assessment of feasibility of technological development. The present development direction and promotion strategy of long term research and development projects are:

a. Research direction

(a) Energy conservation and energy efficiency elevation: including energy conservation technology, elevation of energy efficiency (devices), as well as elevation the rate of resource recovery.

(b) Development and utilization of new energy: including renewable energy, new utilization of energy, as well as energy from waste.

(c) Energy management technology: including investigation of regulations and standards, rationalization of structure of energy payment, design of provision mechanism, modes of energy conservation living, research in cost effectiveness as well as considerations of social welfare.

b. Promotion strategy

Extend organized personnel of research and development. Allocate sufficient

funding for research and development. Institute energy instruction committee of joint ministries by the National Sustained Commission of the Executive Yuan to be responsible for conveyance, integration and assessment. Stress on promoting application and endorsing international cooperation.

4. Better use of energy policy tools

(1) Review the cost of energy and the taxation system to reflect the industrial cost and social cost rationally.

(2) Draw up the electricity law, petroleum management regulation, as well as regulation on emission of greenhouse gases to complement privatization of electricity and petroleum business and to control the emission of greenhouse gases to meet the requirements of the laws.

(3) Through procedures of subsidy, tax reduction and power purchase, emphasize the development and utilization of renewable energy. Laws and regulations actively installed and announced include :"Promotion endorsement regulations on solar thermal water systems", "Installation subsidy regulations on wind power demonstration system facility", "Installation subsidy regulations on solar photovoltaic power demonstration facility", tax reduction and accelerated depreciation on "Rules on promotion of elevation of industry", "Tax reduction rules on applicable investment of installation of energy conservation facilities or application of new or clean energy facilities or technology", "Administrative details on rewarding power generation using methane from landfills of common wastes", and purchase of power from renewable energy sources using price rate of co-generation.

(4) Lower the relative tariffs on natural gas and expand the use of natural gas. Adopt preferential duties which include : reducing the current tariff 3% to 0% on natural gas and levying the half commodity tax on it, and canceling the preferential price of natural gas for fertilizer manufacture. The industrial consumers who use natural gas as fuel don't pay the tax for preventing air pollution.

(5) Promote the energy education in schools, enhance the train and promotion of energy technologies in industries, strengthen the propaganda of energy education toward the public, and encourage the afforestation projects.

5. Emphasize climate monitoring and better use of climate resources

Develop short-term climate forecast technology and promote the application of weather and climate forecasts.

5.3.2 Industrial Process, Utilization of Solvents and Other Products Sectors

The emission of greenhouse gases of industrial processes comes from many different industrial activities. The main emission sources are produced from the different chemical or physical changes in the industrial processes. Through these processes different kinds of greenhouse gases will be emitted. The utilization of solvents and other products would emit NMVOC into the atmosphere because of evaporation. According to the data of green house gas emission from the six categories of Taiwan in 1990 to 1999, greenhouse gases emitted from industrial process with larger quantity are carbon dioxide, halocarbon and hexaflouride sulfur (SF_6), and NMVOC. The emission of methane and nitrous oxide comprises of less than 1 % of the total emission. Carbon dioxide is produced from the process, and halocarbons come from the products using such materials. Hence, the reduction measures of the two categories of industrial process as well as the use of solvents and other products are administered both from the production and consumption sides:

1. Management of stationary pollution sources
    (1) Add the item of carbon dioxide increment to the assessment procedure of environmental influences of major development activities.
    (2) Control the volatile organic matters. Emphasize the development on reduction technology of organic waste in different industrial processes and the research in organic materials with low volatility.
    (3) Endorsement of reduction of emission of volatile organic matters and nitrous oxides from stationary pollution sources.
    (4) Endorsement of installation of oil gas recovery facility in gasoline filling station.
    (5) Promote fuel control and encourage the use of clean fuels. The administration procedure is to limit the use of fuel of less than 0.5 % sulfur content in the metropolitan areas.

2. Environmental management
    (1) In conjunction with the development of environmental management standards, national standards on perceptive environmental management are instituted
    (2) Establish certification and verification system with international compatibility and strengthen the development of local environmental management system.
    (3) Examine the present environmental protection policy and regulation to promote the environmental management profession.
    (4) Establish assessment technology and data bank to help the industry accomplishing environmental management work.
    (5) Disseminate green purchase ideals and promote the system of environmental

emblems.

3. Clean production and green products

(1) Clean production: establish promotion projects on pollution prevention and assist in the development of clean production technology. Disseminate the ideals on clean production and stress on the training of relative personnel. Assist the industry to reduce the emission of greenhouse gases and help to develop technology of reducing the emission of greenhouse gases. Assist the industry to realize industrial waste reduction and elevate the process efficiency. Encourage the middle to small businesses to practice clean production by Chinese satellite system.

(2) Green production: establish technology and data bank of 'Life Period Assessment' to help the industry to promote developmental work on products designed for the environment. Endorse and assist the industry to produce environmentally friendly products. Examine and develop standards on required specifications of green products. Continue to promote the system of environmental protection emblems and stress on follow up assessment work. Continue to promote cross international verification of products with environmental protection emblems. Push for green purchase by the government, and then extend to the big enterprises and the business with ISO certification so that the demand side of green products could be broadened.

4. Reduction procedures on halocarbons and hexaflouride sulfur

(1) Volunteering project by the Taiwan semiconductor business on reduction of PFCs

The Taiwan Semiconductor Industry Association (TSIA) and the World Semiconductor Council (WSC) signed a memorandum on PFCs reduction in April 1999. TSIA agrees to use the emission of 1998 as baseline and will reduce 10 % of PFCs emission by 2010.

(2) Control procedures on ozone layer damaging chemicals

Following the control schedule of the second stage of the Montreal Protocol, the consumption of CFCs is reduced to zero since CFCs are banned from both production and import since 1 January 1996. As for business and supplier of HCFCs, a quota system is being employed and the consumption of HCFCs will be reduced to zero by 2030. Continue administrating the recovery and re-use of CFCs will not only fulfil the goal of reduction of emission but also decrease the impact on insufficient refrigerants. HCFCs substitutes and related technology are introduced and developed. The yearly amount of chemicals banned by the Montreal Protocol consumed in Taiwan is being reported to the ozone secretariat of the Environmental Planning Administration of the United Nations periodically. Enforce the arrest by the related

ministries of the Executive Yuan of smugglers of chemicals banned by the Montreal Protocol. Manufactures of main computer board, personal computers, mouses, etc. in Taiwan are publicized. The use of banned HCFCs products will be prohibited in the manufacturing process as of 1 January 2000. It was announced on 1 January 2000 that fire extinguishers containing the chemical Halon are banned from import. "Ozone Layer Protection Medal" is held every year by the industry, government and academics in Taiwan to award those distinctive in working on reduction of ozone damaging materials or developing alternative technology, prevention of green house effects and improvement of air quality.

5.3.3 Agricultural Sector

According to the data on the emission of greenhouse gases of Taiwan from 1990 to 1999, among the artificial emission sources, 10 % of methane and 92 % of nitrous oxide come from agricultural department. The perceptive procedure on methane and nitrous oxide emission from the agricultural department are as follows:

1. Reduction procedure on methane emission

Although about two-thirds of the greenhouse gases come from combustion of fossil fuels, the amount of the emission of methane only comprised of 1.6 % to 2.5 %. If the average of 2 % is taken for calculation, 8 % of methane in the atmosphere comes from natural and artificial emission sources outside of energy use. Natural emission sources come from wetlands, rivers, oceans and lakes. The changes of emission from natural sources are closely related with human activities.

(1) Agricultural policy

Promote 'Continuation project on utilization adjustment of rice paddy fields'. Work on planned idle cultivation and rotation of paddy fields to reduce the emission of methane from paddy fields and combustion of straws. Continue the promotion of retirement of fruit plantation for forestation or crop conversion. Assist vegetable growing turning to idle or green fertilizer cultivation. Adjust the quantity and method of applying organic fertilizer and chemical fertilizer. Promote the use of biological fertilizer and encourage the production of organic fertilizer from agricultural and livestock wastes as well as cyclic utilization of agricultural waste. Reduce pollution of rivers and underground water and the necessity of energy. Cultivate species with less water and dry tolerant crops. Administrate "Project on adjustment of fertilizer policy". Promote the use of organic fertilizer and biological fertilizer. Promote rational use of chemical fertilizer and develop sustained production from soil.

(2) Livestock industrial policy

(a) Promote reduction of waste in livestock farms and work on recycling of resources, aiming at the goal of zero pollution of the industry.

The future livestock will be majoring in domestic market. It should balance between environmental protection and production, work towards modernized industrial development with high efficiency, high quality and environmentally permissiveness.

(b) Adjusting the structure of livestock industry

The perceptive procedures encourage those livestock farms with small scale, no capability, no motivation to improve their livestock cottages, or farming management to leave the industry. Further, professional livestock farmers are greatly assisted in working on different kinds of methods reducing the emission of greenhouse gases.

(c) Emphasize pollution prevention of the livestock industry

Assist the livestock industry to work on utilizing organic waste. In raising the rate of installing pollution prevention facilities in the livestock farm, pollution monitoring and auditing are emphasized and the treatment rate of excrement from livestock are elevated. Waste reduction is being practiced. Farmers are encouraged to intelligently utilizing biomass energy. Assist farmer group or organization to form livestock waste treatment center, so that waste resources could be recycled for use.

(d) Promote waste reduction and pollution prevention in livestock farms to realization of beautification of environments

Assist industriously the livestock farms to improve their wastewater treatment facilities. Encourage the installation of cleaning facilities on excrements of livestock or concentrated cottages to reduce the pollution. Promote the recycling of wastewater to reduce the use of water on livestock cottages. Assist the recovery for reuse of solid waste from livestock excrement to make biological fertilizer to be used in the farmland for the benefit of land utilization. Assist the farmers to adjust the formula for animal feed. Develop deodorizing technology and use livestock cottages with waterfall or other means of ventilation to reduce the odor concentration and quantity of production. Encourage broad plantation of green belt within the livestock farms to create green and scenic environment that good image of livestock farming could be established.

(3) Fishery policy

Establish designated industrial areas for fish hatchery. Assist the development of

fish hatchery using pure seawater that harmonizes the industrial development with natural environments. Carry out research, development and promotion of all kinds of fish hatchery facility using recycle water.

(4) Methane emission from wetlands, oceans, rivers and lakes

The quantity of methane emission from wetlands, oceans, rivers and lakes is affected by the changing of tides, flooding conditions, conditions of plant growth, and amount of organic matters in soil. The government has begun to pursue the lowering of pollution in rivers. This could decrease the amount of organic matters in the natural surroundings of the wetlands, etc. mentioned above and could help reducing the amount of methane emission.

2. Reduction procedure on nitrous oxide emission

Wetlands, water rice paddies, dry farmlands, treatment of livestock wastes, water leaking from waste landfills, as well as transportation are the main sources of nitrous oxide emissions. In the Taiwan area, the quantity of nitrous oxide emission from land transportation is next to wetland and dry farming. Because land transportation is increasing by the year, so as the amount of nitrous oxide emission thus caused. The feasible reduction procedures at present are:

(1) Agriculture policy

Control the water content in soil (water fields and dry fields) and adjust non-essential water leakage. Regulate irrigation water quantity and method such as intermittent water distribution. Develop slow effective fertilizers. Nurture species with high rate of nitrogen utilization. Continue to promote the inhibition of burning crop residues, assist the farmers in correct treatment or technological utilization on crop residues. Promote ecological environmental protection of water fields and restore underground water replenishment.

(2) Livestock industry

Improve formula for livestock feeds such as low, coarse protein content in feeds could reduce emission of low nitrogen. Assist in effective collection, treatment and reuse of excrement of livestock. Improve management on livestock cottages and feed and research in technology on treatment of excrement of livestock.

(3) Fishery industry

(a) In conjunction with "Administrative project on underground collapse prevention" (1996 to 2000) and "Phase 2 of administrative project on underground collapse prevention" (2001 to 2004), assist in the fish hatchery industry for rational use of water and land resources, lower the ratio of fresh water fish hatchery, and reduce

the usage of underground water.

(b) Promote the regulations on limiting emission of waste gases from fishing boats and strengthen the audit and control of emission of waste gases from fishing boats.

(4) Control of air pollution sources

Strengthen the audit and control as well as collection of air pollution amends for stationary pollution sources and the audit of inspection and adjustment and repair as well as collection of air pollution amends for moving pollution sources.

5.3.4 Land Use Change and Forestry Sector

Forests can absorb carbon dioxide, and the change of land use would increase or decrease the emission of greenhouse gases because of the change of the way of using land. The procedures concerning the land use change and forestry sectors are as follows:

1. Forestry

(1) Emphasize forestation, forest protection and forest improvement: promote the 'National forestation movement principles and administration project', administer administrative project of national forestation movement. Emphasize forestation and restoration on forests. Manage and develop of government and private forests as well as promote and incubate good quality trees. Emphasize forest protection and prevention of forest adversity. Accelerate inspection management of safety forests. Protect forests in reserved areas for aborigines.

(2) Emphasize monitoring and management of water reclamation: perform certification of water reclamation professionals. Emphasize the inspection and reprimand irregular development and utilization of precipice. Work on declaration of special water-resource protection zone. Practice water reclamation monitoring and management. Emphasize education and promotion of water reclamation. Promote balanced utilization of precipice with production, living and environmental protection.

(3) Promote mountain use and disaster prevention as well as integrate planning and management of water collection areas: promote the second phase of mountain use and disaster prevention project. Take water collection area as ecological unit, and using total control principle to limit development, plan mid to long term projects integrating the river water collection areas and realized according to stages and different areas. Establish disaster prevention technology system on precipice and differentiate river water collection areas and wild brooks. Emergency treatment of major disasters in precipice. Water resource protection of mid to small water collection areas. Project on reclamation of ground layer slipping of the Li-Shan area. Reclamation project on

integration of water collection area in the Te-Chee reservoir.

(4) Promotion of projects on forestation and green beautification on plains

Assist low production farmlands to convert to forestation. With direct payment or exchange of land to encourage or subsidize, ecological environments of the city and country could be improved. Construct green corridor, beautify scenery of Taiwan's coast. Construct coastal scenic environmental forests. Build national information system on green resources and network on green education and training.

2. Land Use Change

For the sake of entering the World Trade Organization (WTO) and elevate the international competitiveness of the agricultural products of Taiwan, the government in accordance with the principle of integrated planing of national land, has been promoting the project on releasing farmlands. The quantity of release on farmland is adjusted according to the needs of different departments so that the resource of farmland is rationally distributed to different department. This could benefit the integrated construction of the nations and also lower the emission of greenhouse gases from the agricultural activities on the farmland.

5.3.5 Waste Sector

The waste department includes garbage landfills, wastewater discharge, and the production of the three greenhouse gases of carbon dioxide, methane and nitrous oxide from waste incinerators. Garbage landfill is the largest emission source of methane (above 64 %), the ratio of the total emission of the rest of the two greenhouse gases is not high.

1. Garbage landfills treatment

(1) Control methane emission from garbage landfills

Control the methane emission from garbage landfills according to the "Regulations on common waste landfills facilities" of the laws on waste treatment.

(2) Promote the recovery of methane for reuse from landfills

According to the 'Administrative procedures on encouragement of methane power generation from common waste landfills by the Environmental Protection Administration of the Executive Yuan', methane power generation plants are given monetary awards, and the power generated can be sold to the Taiwan Power Company. At present, there are methane power generation from Shan-Chu-Koo landfills in the Taipei City and Si-Ching-Pu landfills in the Kaohsiung City.

2. Promote the project of construction of incinerators

The government is actively promoting incinerators as the major method of garbage treatment. In the first stage to be completed in 2002, 21 incinerators will be built. At present, 8 incinerators have been installed. The government is to process to pursue the second stage in which 15 incinerators will be constructed. When completed, the incinerated rate of garbage in Taiwan would reach 9 %, and installation of incinerators would help reduce the methane emission.

3. Wastewater discharge

(1) Green beautification of rivers

The present work on green beautification of rivers include pollution renovation project of Tan-Shui River, beautification project of Er-Chung Flood Control Channel and green beautification project of high banks of rivers, etc. This could reduce the methane emission from this department.

(2) Control of sources of wastewater pollution

Emphasize the controls of pollution source of wastewater and emission reduction. Reduce the organic pollution from water emission from fishery hatchery and the quantity of excrement from the species in the hatchery. Promote the pollution control aside from point sources. Strengthen the construction of public sewage system. Proceed renovation work on pollution from oceans, rivers and lakes.

(3) Research and development of clean manufacturing technology

Pursue technology of pollution prevention and reduction of industrial waste, introduce clean manufacturing technology and wastewater treatment technology with high efficiency and not occupying space.

Chapter Six: Research, International Cooperation, Education & Public Awareness

6.1 Research

The government of the Republic of China (Taiwan) attaches great importance to the research and development of science and technology. R&D investment has exceeded 1% of GDP since 1984. In 1997 it reached 1.9%, totaling NT$156.3 billion (about US$5 billion). The major organizations responsible for researching climate change and greenhouse gas emissions are (1) the National Science Council (NSC), (2) the Environmental Protection Administration (EPA) and other agencies. The NSC is mainly responsible for promoting basic scientific research, while the EPA and other agencies for promoting application-oriented research on relevant executive and policy-making matters. Academic or research institutes are usually commissioned by government agencies to carry out research. The current situation concerning basic and applied scientific research projects undertaken by academic research institutions is outlined below:

6.1.1 Basic Scientific Research

Climate change drew the attention of scientists early on and as a result related research got under way internationally and in Taiwan fairly early as well. Major international research projects relating to climate change include three networks : the International Geosphere-Biosphere Program (IGBP) promoted by the International Council of Scientific Unions (ICSU), the World Climate Research Program (WCRP) promoted by the World Meteorology Organization (WMO) and the International Human Dimensions Program on Global Environmental Change (IHDP) promoted by the International Social Science Council (ISSC). Taiwan's scientific community has participated in each of the three networks since Global Change academic research began in 1989. The IGBP was the first project that focused on climate change undertaken by the NSC. In order to advance this project, the Academia Sinica set up the "China (Taipei) IGBP Committee" (IGBP-ROC) in September 1988. The IGBP-ROC is now a member of the IGBP. The "Global Change Task Force" was established under the "Environment and Development Committee" of the NSC in June-1994. In November 1994, a five-year medium range plan was completed. The "Global Change Task Force" was renamed the "Sustainable Development Research and Promotion Committee" in 1997. It has promoted global change studies across other different fields. It also enables the collaboration and interchange

between specialists from the humanities (such as economics and environmental engineering) and engineering sciences. The objectives of the medium range plan are to:

1. Understand the impact of global change on Taiwan's natural environment;
2. Obtain regional data so as to understand the operation of the earth system and the processes of global change;
3. Set up regional climate and environmental models so as to forecast future changes;
4. Provide needed environmental data, keep in line with the international convention on preventing global change, and make suggestions on feasible proposals to meet the requirements in the convention;
5. Evaluate the impact on Taiwan's economy and social system from the changes of the climate and natural environment, provide response strategies, including prevention and adjustment measures, and draft a blueprint for Taiwan's sustainable development.

Under the five-year framework plan for global change research, the NSC subsidized 740 large-scale research projects on global change in the six years between 1994 and 1999. There have been about 14 groups of projects each year in recent years. Total research funds over those six years exceeded NT$1 billion. There are more than 100 project leaders guiding global change research and several hundred researchers involved. Fields included cross the lines between nature studies, biology, engineering and the humanities. It is the biggest and most important agency in Taiwan's governmental efforts in global environmental change research. This demonstrates the value the R.O.C. government puts on research into global change. The project can be divided into the following 7 groups:

1. Atmospheric chemistry and radiation
2. Ocean circulation
3. Ocean flux
4. Climate change and forecasting
5. Past environmental change
6. Hydrological cycle and global change
7. Global environmental change research in the humanities and social sciences

The above-mentioned seven topics and sub-projects relating to them coordinate in principle with the core projects of the IGBP. As a result, nearly all of the research groups have a corresponding international academic society. Some members of the research groups further play important policy-making roles in these international organizations. In the future, the project will focus on the impact of climate and environmental change, on mitigation strategies for alleviating the impact and on appropriate adjustments that Taiwan should implement. Future

plans include establishing an observation and monitoring system, understanding processes and causes, using models for forecasting, evaluating and responding to the impact of change, participating in international collaborative research. This also demonstrates Taiwan's dedication and contribution to global climate change research.

Numerous results have accumulated since the start of many global change studies in 1989. An initial atmospheric chemistry monitoring system has been set up in Taiwan and adjacent areas. Monitored data are processed allowing detailed evaluation of global climate change's impact on Taiwan's environment and ecology. Human factors in global environmental change have been studied as well. We have already come to understand well the climate system. In recent years, the NSC has encouraged local academics to take part in international organizations and events by means of the "International Participation in Global Change" program so as to raise the R.O.C.'s status in the international community and to improve academic research standards. The "Global Change Communication, Forum and Global Information Network" program enables domestic academics to understand advances in different fields, enhances interchange between fields, inspires more in-depth study by allowing information exchanges with local or foreign academics via the Internet, and also provides that expertise to non-expert policy makers.

6.1.2. Application-oriented research

1. EPA greenhouse gas investigation and study of reduction strategies

   The EPA has made every effort since it was established in 1987 toward participating in international environmental affairs. In order to coordinate with the UN Montreal Protocol, which controls substances that deplete the ozone layer, the EPA set up a "Montreal Protocol Task Force" to meet future national environmental quality targets and to adjust to the international environmental protection trend in August 1991. The "National Environmental Protection Plan" was produced, covering short-, medium- and long-term action plans for reducing greenhouse gases in August 1997. In addition, the EPA drafted Taiwan's "Agenda for the 21st Century" in line with the international trend of sustainable development. It is clear that Taiwan's response to climate change has transformed from basic reaction to the level of sustainable development.

   The EPA approaches research into climate change from the position of policy-making. It has conducted greenhouse gas reduction evaluations and formulated environmental impact, adjustment, response and control strategies. From 1991 to 1995, the EPA focused on surveying greenhouse gases, impact assessment, setting up a technological information database and planning. From 1995 to 1998, the EPA focused on studying adjustment strategies, strategies for reducing greenhouse gas emissions, assessing economic impact and conducting cost benefit analyses of different control mechanisms.

In 1998, the NSC and the EPA jointly formed an inter-agency task force for promoting academic cooperation. Funded from fees on air pollution, the NSC conducted an technology project supported by the fund of air pollution prevention tax. In the three years between 1998 and 2000, a total of NT$330 million was allocated to 283 projects. Four major projects were planned to respond to the framework convention on climate change. They are "Energy policy and industrial restructuring," "Functional evaluation of forest reserve as greenhouse gas stores," "R&D of carbon dioxide fixing technologies" and "Determining flux in greenhouse gases and reduction countermeasures." A total of 69 projects were approved with a total budget exceeding NT$70 million.

Basic data relating to climate change in Taiwan have been acquired through these projects. Projections on greenhouse gases, impact reduction analyses, response strategies and other basic data needed for the National Communication Report were obtained. Meanwhile, recommendations were made to the government on strategies such as energy conservation, raising energy efficiency, reviewing the energy supply structure and industrial restructuring. In addition, preliminary methods have been developed to fix carbon dioxide through chemical and biological technologies. In the future, planning will be carried out on the greenhouse gas situation, possible reduction mechanisms and clean energy, done in the expectation that research results will yield reasonable, effective and low-cost response and control strategies.

2. Research into energy and greenhouse gas reduction

The Energy Commission (EC) of the Ministry of Economic Affairs is the agency responsible for drafting the R.O.C.'s energy policy. In responding to the impact on Taiwan's energy use of the United Nations Framework Convention on Climate Change (UNFCCC), from 1992 the EC has conducted a "Research project on energy strategies to control carbon dioxide emissions," including measures involving energy and industrial development, energy supply restructuring, and economic impact assessments. In addition, the EC has conducted research into "man-made greenhouse gases in the Taiwan area" and "post-UNFCCC analysis." Because energy policy touches on many areas, the EC is continuing to conduct research into energy market liberalization, raising energy efficiency, promoting co-generation, energy conservation, developing new and clean energy and evaluation of economic incentives, so as to meet targets of lowered carbon dioxide emissions and to stabilize domestic energy use.

In order to understand the UNFCCC's impact on Taiwan's industry, from 1992 the Industrial Development Bureau (IDB) of the Ministry of Economic Affairs first focused on the chemical industry, which emits large quantities of carbon dioxide, and promoted a five-year research plan on reducing greenhouse gas emissions from chemical processes. The results include the setting up of a CO_2 emission model for industrial processes, estimations of the proportion of total CO_2 emissions coming from chemical-related industries

(petrochemicals, steel, cement, plastics, rubber, fertilizer, pesticides, basic chemistry, chemical fibers, etc.), and suggestions of industrial responding strategies. The IDB also conducts research on CO_2 recovery, storage and reuse overseas.

In order to realize the conclusions of the "National Energy Conference" held in May 1998 and in December 1999, the NSC and EC completed the "Long Term Energy Technology Development Plan". The key points of this project are:

(1) Energy conservation and raising energy efficiency, including energy conservation technologies; raising energy efficiency (of equipment); raising efficiency of resource recycling.

(2) Developing and utilizing new energy sources, including renewable energy; developing new uses for energy; researching energy produced from waste.

(3) Energy management technology, including drafts of code and standard; energy pricing structure rationalization; design of incentives mechanisms; energy-saving lifestyle; cost effectiveness studies; consideration of social welfare.

(4) Promotion strategies and measures, including enlarging R&D manpower and allocating sufficient fund for R&D. The purpose is to adjust Taiwan's energy supply structure and reduce CO_2 emissions through energy conservation, use of clean forms of energy, increased efficiency and proper management.

3. Research into forecasting climate change

In January 1994, in response to climate change in Taiwan, the Central Weather Bureau (CWB) of the Ministry of Transport and Communications set up a "Climate Change Working Group." This group collects data and carries out analyses in five areas: the impact of rising sea levels; Taiwan climate data analysis (including standard meteorological factors as well as data on carbon dioxide and other greenhouse gases); changes in weather patterns; meteorological disasters; numerical simulations. In 1998, the group carried out a project on "the Effect of Global Climate Change on Taiwan's Use of Water Resources and Agricultural Production". In the future, the CWB will continue to compile a regional climate database, improve climate monitoring, introduce and develop global and regional numerical models, track climate change, explore the relationship between change in the Taiwan region and elsewhere, and look into the causes and processes of climate change and its future trends.

4. Research into the influence of climate change on water resources

In light of the impact of climate change on water resources, in 1995 the Water Resources Bureau carried out a study of the influence of climate change on water resources as well as an impact assessment and research into response strategies. In the same year, the Water Conservancy Agency (WCA) carried out experiments and drew up comprehensive

plans on advance warning installations for long-term changes to water resources and coastal change. It also studied the impact of global climate change on water resources in the Taiwan area. In 1996, the WCA conducted assessments of the impact of global climate change on Taiwan's runoff; an investigation and analysis of river basin water resources and changes in the ecological environment using the Houlung River as a case study; investigation of climate change and tree growth ring indices. In 1997, the Water Resources Bureau conducted research into sustainable development of water resources in coastal regions and management of maritime water resources as well as planning to prevent coastal disasters.

5. Research into the influence of climate change on agriculture

In its response to global warming, apart from strengthening current forest resources, the Council of Agriculture (COA) under the Cabinet has also been promoting afforestation projects for the general public and sought assistance from overseas. It is expected that in 2001 afforestation will have been carried out on 61,000 hectares, reducing atmospheric carbon dioxide by 8.27 million tons. The level of Taiwan's forest coverage will rise from 58.5% to 60.2%, from eighth in the world to fifth.

The "Project to strengthen forest ecosystem operations" is being undertaken by the Forestry Bureau, Taiwan Forestry Research Institute, Veterans Affairs Commission Forestry Department, National Taiwan University, National Chunghsing University and Chinese Culture University. Through its experiments, the project has drafted a regional forest ecosystem operations plan, proposed appropriate operation strategies for current forest resources so as to reach the target of sustainable forestry operations that are ecologically healthy and meet the demands of society.

In 1998, the "Research Project into Climate Change" was launched, investigating the forestry, livestock, arable and fisheries sectors and drafting response strategies for the agriculture industry.

The influences of climate change on forestry production can be summarized as 1) Changes in productivity; 2) Movement in areas planted; 3) Repeated interference; 4) Changes in development of the forestry industry. Consequently, forestry operations and resource planning to respond to developments in society and human activities should research and develop in the following areas:

(1) Establish the concepts of sustainable forestry development and high-forestation and promote concepts of protecting forest resources and the natural environment.

(2) Strengthen management of current forestry operations to increase forest density and build up carbon sink.

(3) Carry out long-term research into forest ecosystems and develop research systems and strategies for running forest ecologies that are appropriate for Taiwan's

environment.

(4) Raise self-sufficiency and sustainability of timber resources, carry out classification of forestland, strengthen follow-up cultivation in man-made forests, plan timber production zones and adopt conservationist approach.

(5) Promote afforestation and "greening" of industrial and urban areas so as to increase Taiwan's absorption via photosynthesis of carbon dioxide.

(6) Implement energy replacement plan including developing use of forestry products and of biomass fuels to replace fossil fuels so as to greatly reduce CO_2 discharges, encourage increase in the area of forest coverage, strengthen carbon soil content in forests, promote recycling of carbon fuels.

6.2 International cooperation and exchange

The greenhouse effect and climate change are global environmental problems. A concerted international effort is needed to ease the environmental impact. International exchange is needed therefore if collaborative international research, technology transfers, greenhouse gas emissions trading, joint reductions, fiscal support and political communication are to succeed. For political reasons, Taiwan is unable to become a UN member. Hence, although Taiwan has greenhouse gas reduction technology and a foundation in climate change research, the country is still unable to dedicate itself in the way that signatories to the Framework Convention on Climate Change can. Taiwan can currently only exchange and cooperate with other nations on related matters through civil groups.

6.2.1 Participation in international organizations

Participation in international organizations is an essential and important part of international exchange. The regular activities of such groups can boost cooperation and mutual help between nations. Taiwan is currently a formal member only of "Global Change" international research groups such as the International Geosphere-Biosphere Program (IGBP) Science Committee on which Taiwan is represented by the Academia Sinica. IGBP is built around a number of core projects including GCTE (Global Change and Terrestrial Ecosystems), DIS (Data and Information Services), LOICZ (Land-Ocean Interactions in the Coastal Zone), IGAC (International Global Atmospheric Chemistry Project), JGOFS (Joint Global Ocean Flux Study) and PAGES (Past Global Changes). Each of these projects has a working committee. Taiwan is now a member of almost all of the afore-mentioned bodies. In addition, the National Science Council is a member of the International Group of Funding Agencies for Global Change Research (IGFA). National Taiwan University's Global Change Research Center is an international resource center for the IGBP's IGAC and ARARE core projects; researchers from

China, Hong Kong, Japan, South Korea and the United States are participating in this project.

In 1991, before the United Nations Framework Convention on Climate Change was signed, Taiwan participated in the third and fourth conference meetings of the inter-governmental negotiating committee. Taiwan had NGO observer status under the name of the non-governmental Industrial Technology Research Institute. Taiwan subsequently participated in the 1992 Earth Summit. From 1993, Taiwan attended meetings of the FCCC subsidiary bodies (Subsidiary Body for Scientific and Technical Advice and Subsidiary Body for Implementation) and from 1995 attended the FCCC treating signing international conferences.

6.2.2 Participation in international activities

As the collaborative international research plan into global climate change requires regular coordination, since 1992 Taiwan has participated in more than 30 scheduled conferences relating to the project, including those of the IGBP and its core projects, IGFA, the World Climate Research Program (WCRP). Taiwan has come to have a more and more important position in these organizations and conferences. In particular, in recent years Taiwan has participated in the activities of regional organizations. Most important of these is the Southeast Asia Regional Committee (SARCS) under the Global Change System for Analysis Research and Training (START), which has made a concrete contribution toward research into regional environmental and ecological change. A summary of Taiwan's participation in international activities follows:

1. 1988 – Taiwan participated in the first Scientific Advisory Council meeting (SAC-1) of the IGBP.
2. 1991 – The National Science Council and IGBP-ROC attended the IGBP Asia Working Meeting in India, presented a comprehensive national report and explained Taiwan's research projects relating to Global Change.
3. 1992 – An observer team consisting of academics brought together by the National Science Council attended peripheral meetings at the Earth Summit. In the same year, the National Science Council commissioned National Taiwan University's Institute of Oceanography to convene a meeting of the Scientific Steering Committee of the Joint Global Ocean Flux Study (JGOFS-7) in Taipei.
4. 1993 – PAGES seminar held in Taipei.
5. 1994 – The National Science Council organized the sixth IGFA conference in Taipei.
6. 1995 – Participated in START's SARCS-6 and SARCS-7 conferences and the IGBP's SAC-4 meeting.
7. 1996 – Attended START's SARCS-8 meeting and the SARCS/START/APN Global Change Science and Policy Forum.

8. 1997 – Attended START's SARCS-9 meeting.

9. 1998 – Provided US$20,000 to START for use in the joint seminar organization; participated in the second meeting of the South China Sea Monsoon Experiment (SCSMEX), the TOGA-TAO Panel meeting, the twelfth SRACS meeting, and GCTE, LTER and APARE meetings.

10. 1999 – Provided US$20,000 to START for use in the joint seminar organization; attended the IGBP's SAC-5 meeting, SCSMEX oceanography working group meeting, LUCC conference organized by SARCS, TRMM science subcommittee meetings, all related to the international Global Change project, which had a positive significance for raising Taiwan's position in the project.

The Energy and Resources Laboratories of the Industrial Technology Research Institute, with the help of the Environmental Protection Administration, became a member of the International Emissions Trading Association (IETA). IETA is a non-official, not-for-profit body set up by UNCTAD (the UN Conference on Trade and Development) and the Earth Council. Its purpose is to promote information and exchange of experiences about the Kyoto framework to international businesses. IETA currently has nearly 40 well-known international enterprises as members. The information and channels provided by this association will help Taiwan respond to the FCCC as well as increase opportunities to participate in international cooperation.

Taiwan's EPA has cooperated with the EPA in the U.S. on the "Energy Star" project, a good example of international cooperation. The Energy Commission has also begun to set bilateral technological cooperation in motion. Current prospective partners are the Netherlands, the United States, Japan and Denmark. This will expand Taiwan's opportunities for participating in international cooperation in response to global climate change. The Asia Pacific Economic Cooperation (APEC) forum Energy Group expects to start next year estimating the possibility of cooperation in the Asia Pacific region's response to the greenhouse effect, with clean development systems given priority. As an APEC member, Taiwan endeavors to join this project.

6.2.3 Technological needs

The Taiwan area is an island and is fairly vulnerable to the environmental changes brought by climate change. In striving to raise standards of living over the past 30 years, Taiwan has put all its efforts into economic development. Applied research into environmental renewal, sanitation and ecological preservation has lagged behind. Taiwan consequently now needs technological support on strata subsidence, developing water resources, sanitation and ecological restoration and preservation. Further, since Taiwan relies heavily on imported energy, it plans to development progressively cleaner and more modern energy technology. However the costs of this kind of technology are high and there will be difficulties meeting the target. So

Taiwan needs to ask developed countries for support on new, clean energy technologies.

6.3 Education and public awareness

Greenhouse gas emissions, climate and environmental change and other factors linked to global warming do not just belong in the realm of scientific research. Since the causes of climate change cross national boundaries, they will have a political and economic impact on every nation. To avoid the trend of continued global warming, "policy coordination" and "national participation" are even more important than scientific research and technological countermeasures. Hence the topic of global warming needs to have not just consideration and input from researchers, but it also requires the awakening of the whole population's environmental consciousness. Consequently we must rely on schools and all aspects of education in society. A survey in 1996 found that: "30-50% of junior high school to university students have the most basic understanding of global climate change; around 45% of university graduates have equivalent knowledge. Nevertheless around half of people in society have less than the knowledge of average junior high school student." It is apparent that in the near future the emphasis will be on education in schools on global warming while education in the rest of society will wait to be strengthened.

6.3.1. Environment science education

The National Science Council, when mapping out a five-year medium range Global Change plan in 1994, proposed the following popularization measures for education and public awareness:

1. Elementary and junior high school teacher training: training can be given through cooperation with environmental education departments of teacher training colleges; additionally, information on Global Change can be incorporated into training meetings for teachers and administrative personnel.
2. Hold regular meetings to publicize research results, workshops to spread information and seminars to introduce concepts for the public and media.
3. Publish a series of introductory books and produce related films: Compile a series of popular science books to convey the importance and relationship to Taiwan of research on Global Change; television films could also be produced to explain in a vivid way all aspects of Global Change. In addition, the concepts of sustainable development could be included in school textbooks.

6.3.2. Environmental education in schools and society

In 1990, the Ministry of Education established an "Environmental Protection Division" to lend an impetus to environmental education and pollution prevention work at all levels of schooling. The division was also given responsibility for integrating and assessing the education system at all levels as well as the environmental protection education work of all parts of the Cabinet. The Environmental Protection Division at the Ministry of Education recognizes the role that should be played by education in the nation's sustainable development. It produced "Entering the 21st Century – A strategy of Environmental Education for Sustainable Development" which contains three goals : (1) Abide by the nation's basic constitutional policy while advancing education in sustainable development (2) make the whole population recognize environmental problems, understand and care about the relationship between man and the living environment and participate in maintaining the ecological balance and the quality of the environment; and (3) foster environmentally-aware citizens through education who have the principles, knowledge, attitude, abilities and values needed for environmental protection and improvement.

The Environmental Protection Administration's Comprehensive Planning Bureau established an "Environmental Education and Public Awareness" unit with responsibility for promotion of awareness of environmental protection policy and laws and environmental protection measures and, through schools and other channels in society, to strengthen environmental education.

In 1997, to raise the quality of Taiwan's environment and to adjust to the international tide of environmental protection, the EPA introduced the "National Environmental Protection Plan." This contains three-stage objectives for Taiwan's environmental protection education and public awareness:

1. Short-range objective (Year 2001): Priority on promoting policies currently being carried out by the EPA and environmental protection measures easily carried out by individuals.
2. Medium-range objective (Year 2006): Gradually foster spontaneous environmental protection activities among the public; guide activities to resolve problems.
3. Long-range objective (Year 2011): Environmental protection is well engrained as a habit in society and environmental principles take root.

Education and public awareness schemes relating to reducing greenhouse gases emissions currently being by followed by the EPA include : spreading awareness of regular testing of vehicle exhausts; spreading awareness of pollution control technology for fixed pollution sources and of clean fuel; encouraging companies to conserve energy, increase energy efficiency, promoting electricity co-generation and renewable energy sources; researching a carbon tax or energy tax and emissions trading systems as a way to guide industry to develop low energy consuming and clean production methods; strengthening training of researchers and advisers for

environmental education, seed teachers and volunteers; single window access for education and public awareness work; producing educational materials appropriate for different groups in society and all age groups, with different topics and locations; strengthening education, training and communications with target organizations; participating in international exchange activities and international collaborative projects.

6.3.3. Schools and civil groups

The number of courses on climate change in Taiwan' s colleges has already started to rise, showing that colleges are progressively spreading education of climate change. In addition, there are now over 50 civil environmental protection organizations. Since these groups have much in common and many members, they can form the core of environmental education. The environmental education they set in motion in society will penetrate even more deeply and effectively. Currently, most civil groups in Taiwan stress local environmental pollution problems or ecological protection. Activities include publishing, holding forums and lectures, producing and spreading television programs. Some organizations focus on bigger environmental problems, maintain links overseas, hold Earth Day activities and so on. In short, schools and civil organizations have an indispensable part to play in education and raising public awareness of climate change.

References

1. Chang-Hung Chou, Michael Hsiao, Yen-Wen Kuo, Shin Wang, Yu Yue-Hwa, Huang Jong-Tsun, Yang Kuan-wen, Huang Cheng-chieh, Edwin Yen; 1991, *Draft framework on Taiwan's environmental education*, R.O.C. First Academic Symposium on Environmental Education.
2. Wu Ming-chin, Tsuang,Ben-Jei, Liu Chi-Ching, Chen Hsieh-Huang; 1995, *Regional climatic change in Taiwan*, Global Change Report 7.
3. Chang Ssu-Li; 1995, *Investigation of the interrelations between Taiwan's energy, environment and economic development*, MOEA Energy Commission.
4. Chung-Ming Liu; 1995, *Planning and advancing investigation into regional and global climate change in Taiwan*, Environmental Protection Administration.
5. Chiang Shan-Hsin; 1993, *Global environmental change (part 1)*, Environmental Education.
6. Chen Yeong-ren, Liu Chia-chun; 1993, *Taiwan's environmental education policy and experience of environmental promotion*, Environmental Protection Administration, Comprehensive Planning Bureau.
7. Yen-Wen Kuo; 1995, *Summary of investigation into the National Science Council Science Education Division's promotion of environmental education*, NSC Science Education Division Monthly.
8. Environmental Protection Administration (Executive Yuan); 1998, *R.O.C. Taiwan area environmental protection annual report*.
9. Environmental Protection Administration (Executive Yuan); 1997－99, *Framework Convention on Climate Change update reports.*
10. MOEA, 1998, Data from the National Energy Conference.
11. Council for Economic Planning and Development (Executive Yuan), 1998, Sustainable National Development Forum
12. Kon-Kee Liu, Chang-Hung Chou, Song-Chin Lin, Jao-Jia Horng, Daigee Shaw; 1994, *Global Change research five-year medium-range plan – Taiwan's current situation and prospects*, National Science Council Environmental Development Committee.