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Energy Saving and Carbon Reduction Policy in Taiwan

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1. Introduction

As the international energy situation undergoes sharp changes, greenhouse gas emissions and the safety of energy supplies become the most pressing challenge of energy supply and demand. In this era of the Kyoto Protocol and high oil prices, all countries in the world have put forward reduction strategies for CO₂ emissions, including such as developing high-value and low-carbon industrial structures, increasing the energy utilization efficiency of various sectors, and constructing reasonable and effective policy tools for the sustainable development of energy sources, environmental protection and the economy.

As the post-Kyoto Protocol era looms ahead, even though Taiwan is not yet a signatory and is presently free from the pressure of being subjected to a greenhouse gas reduction time limit, as a member of the global village, it still needs to exhibit a sense of responsibility to the international community in protecting the earth. In recent years, Taiwan has referred to the energy balance sheet and the statistical data in the websites of the Environmental Protection Administration and the Ministry of Economic Affairs under the Executive Yuan, and uses the IPCC method to estimate data on greenhouse gas emissions based on reference and sector methods. The Environmental Protection Administration of the Executive Yuan is the present competent authority for the statistics of greenhouse gas emissions, but the statistics of CO₂ emissions derived from energy use are estimated by the industry competent authority, the Bureau of Energy of the Ministry of Economic Affairs before being compiled by the Environmental Protection Administration of the Executive Yuan.

Table 1 show that the total greenhouse gas emissions of Taiwan increased gradually from 150 million MT CO₂ equivalents in 1990 to 300 million MT CO₂ equivalents in 2007, and then decreased to 270 million MT CO₂ equivalents in 2009. The CO₂ emissions accounted for about 90% which increased from 120 million in 1990 to 270 million MT in 2007. It has been decreasing each year since 2008, and it was 250 million MT in 2009, a decrease of 4.7%. That derived from energy use (fuel combustion) accounted for a large proportion, and the emission was 240 million MT, a decrease of 4.9%.
Table 2 shows the CO₂ emission intensity in Taiwan, the CO₂ emissions per one million NT dollars of real gross product of Taiwan in 2009 was 19.6 MT, a decrease of 0.6 MT as compared with the figure for 2008; the CO₂ emissions per capita were 10.9 MT, a decrease of 0.6 MT.
| Year | CO2 Emissions | Emissions Per Person | CO2 Emissions Intensity ratios |
|------|---------------|----------------------|-------------------------------|
|      | Kiloton       | Growth rate (%)      | (Per-person-kt CO2) (kg CO2/NT$) |
| 1990 | 122,399       | 2.10%                | 6                             | 0.023 |
| 1991 | 131,853       | 7.72%                | 6.4                           | 0.023 |
| 1992 | 141,259       | 7.13%                | 6.8                           | 0.0229 |
| 1993 | 152,725       | 8.12%                | 7.3                           | 0.0232 |
| 1994 | 160,162       | 4.87%                | 7.6                           | 0.0226 |
| 1995 | 167,308       | 4.46%                | 7.9                           | 0.0222 |
| 1996 | 175,754       | 5.05%                | 8.2                           | 0.0221 |
| 1997 | 188,951       | 7.51%                | 8.7                           | 0.0225 |
| 1998 | 198,340       | 4.97%                | 9.1                           | 0.0229 |
| 1999 | 207,130       | 4.43%                | 9.4                           | 0.0225 |
| 2000 | 224,661       | 8.46%                | 10.1                          | 0.0231 |
| 2001 | 230,576       | 2.63%                | 10.3                          | 0.0241 |
| 2002 | 239,593       | 3.91%                | 10.7                          | 0.0238 |
| 2003 | 248,599       | 3.76%                | 11                            | 0.0238 |
| 2004 | 257,279       | 3.49%                | 11.4                          | 0.0232 |
| 2005 | 263,819       | 2.54%                | 11.6                          | 0.0227 |
| 2006 | 271,774       | 3.02%                | 11.9                          | 0.0222 |
| 2007 | 274,973       | 1.18%                | 12                            | 0.0212 |
| 2008 | 263,606       | -4.13%               | 11.5                          | 0.0202 |
| 2009 | 251,149       | -4.73%               | 10.9                          | 0.0196 |

Source: Environmental Protection Administration, ROC(2010)

Table 2. CO2 Emissions from Fuel

The energy supply/demand has grown rapidly in Taiwan over the past two decades. The total CO2 emissions of fuel combustion in Taiwan in 1990 calculated by the sector method was 122,399 thousand MT; it was 224,661 thousand MT in 2000 and 274,973 thousand MT in 2007, but it decreased to 263,606 thousand MT in 2008 and even further to 251,149 thousand MT in 2009. It decreased by 4.13% in 2008 from 2007, marking the first decrease. It decreased by 4.73% in 2009 from 2008. The figure 1 illustrates the trends of CO2 emissions from 1990 to 2009.
The emission decrease of the most recent years resulted from the financial storm in 2008 which reduced industrial activity, although the energy consumption of various major industries recovered gradually as prosperity revived in 2009. The government has been promoting energy-saving measures since 2008, with energy consumption continuing to evince negative growth. The annual growth rate of 10.29% in 2000 was the highest between 1990 and 2009, followed by the figure of 8.2% in 1991, whereas the positive growth rate of 1.36% in 2007 was the lowest.

According to the data of the Directorate General of Budget, Accounting and Statistics, CO2 emission rate per capita was about 6.0 MT in 1990, 10.1 MT in 2000, and 12 MT in 2007; it decreased to 11.5 MT in 2008, and further decreased to 10.9 MT in 2009. The figure 2 shows the trends of CO2 emissions per capita. The average growth rate of emission per capita between 1991 and 2009 was about 3.4%, but in 2009 it decreased by 5.2% from 2008. In addition, the CO2 emission intensity (i.e., CO2 emission per unit GDP) was 0.023 kg in 1990, 0.0231 kg in 2000, 0.0212 kg in 2007, 0.0202 kg in 2008, and 0.0196 kg in 2009. The emissions in various years and related indexes accounted for about 1% of global emissions, for Taiwan a ranking of 22nd in the world. The figure 3 shows the CO2 emissions intensity form 1990 to 2009.
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Although energy use decreased as a result of the implementation of various policies in this period, the outcome was not as good as expected for the following reasons: (1) the energy structure has changed, with the proportion of coal with a high carbon content of the overall energy supply continues to increase; (2) the energy price adjustment and tax review policy failed to be implemented effectively, the industrial energy-saving inducement was reduced, and the improvement of energy productivity was obstructed; (3) with respect to energy use and greenhouse gas emission baseline investigation and verification systems, though expected goals were realized, the overall effect still needs to be improved; (4) due to policies promoting the liberalization of the energy industry during the last two decades, many private enterprises in the oil refining and power generation industries have emerged; these enterprises usually use low-cost coal in consideration of their costs, so that the CO₂ emissions have markedly increased.

The fuel combustion CO₂ emission rates of different sectors of Taiwan in 1990 are shown in Table 3 with the energy sector accounting for 45.74%, the industrial sector for 27.26%, transportation for 17.55%, agriculture for 2.63%, housing for 3.59%, and the service industry for 3.23%. In 2009, the energy sector accounted for 65.94%, the industrial sector accounted for 15.90%, the transportation accounted for 13.96%, the agriculture accounted for 0.41%, the housing sector accounted for 2.07%, and the service industry accounted for 1.72%, with the energy sector having the maximum growth rate of energy consumption. Although the carbon emissions of the other sectors all increased, the carbon emission ratios of the sectors other than the energy sector decreased.

Figure 1 shows the data for CO₂ emissions derived from energy consumption in Taiwan for the period 1990-2009. Basically, the emission rate has been increasing linearly since 1990; the annual growth rate is about 11 million MT, even at several key points in time. For example, when the Kyoto Protocol was signed in 1997, and when the Kyoto Protocol went into effect in 2005, the greenhouse gas growth curve of Taiwan continued to develop as before without showing any effect. It is obvious that energy saving and carbon reduction measures undertaken in Taiwan remain inconspicuous.

2. The existing circumstances of energy consumption of various industries in Taiwan

The economic development trend in Taiwan of recent years shows the structural changes of tertiary industry, with the gross product of the industrial sector decreasing year after year, uniting for only 31% of gross product of Taiwan in 2008, whereas the proportion of the service industry has increased continuously, rising to 68% in 2008.

2.1 The structure of energy consumption in Taiwan

The structure of energy consumption in Taiwan is as follows: 98% of Taiwan's energy is imported. Imported petroleum is higher than 99.9%. The energy consumption ratios of different sectors in 2009 are: industry 52.5%, service industry 11.5%, transportation 13.2%, housing 11.6%, energy 7.2%, agriculture 0.9% and non-energy use 3.1%. Figure 5 illustrates the structure of total domestic consumption.
The structure of energy consumption in Taiwan is as follows: 98% of Taiwan’s energy is imported. Imported petroleum is higher than 99.9%. The energy consumption ratios of various industries in Taiwan in 2009 are: industry 52.5%, service industry 11.6%, energy 7.2%, agriculture 0.9% and no energy use 3.1%. Figure 5 illustrates the different sectors in 2009 are: industry 52.5%, service industry 11.5%, transportation 13.2%, agriculture 2.63%, housing 3.59%, and the service industry accounted for 1.72%, with the tertiary industry having the maximum growth rate of energy consumption. Although the transportation sector accounted for 2.07%, and the service industry accounted for 1.72%, with the energy sector accounting for 45.74%, the industrial sector for 27.26%, the agricultural sector for 4.52%, the residential sector for 4.78%, and the service sector for 3.23%. In 2009, the energy sector accounted for 65.94%, the industrial sector accounted for 27.26%, the agricultural sector for 3.23%, the residential sector for 3.59%, and the service sector for 1.72%. The economic development trend in Taiwan of recent years shows the structural changes of the various industries in Taiwan. The tertiary industry has increased continuously, rising to 68% in 2008, whereas the proportion of the industrial sector decreased year after year, uniting for only 31% of gross product of Taiwan in 2008, whereas the proportion of the service industry has increased continuously, rising to 68% in 2008.

2.1 The structure of energy consumption in Taiwan

The fuel combustion CO₂ emissions have markedly increased. Table 3 with the energy sector accounting for 219,855 Kt, industrial sector for 195,384 Kt, transportation for 215,488 Kt, agricultural sector for 32,914 Kt, residential sector for 199,775 Kt, service sector for 218,976 Kt, total CO₂ emissions from energy consumption in Taiwan for 2001 was 1,102,135 Kt, and the CO₂ emissions from energy consumption in Taiwan for 1990 were 325,859 Kt. The emission rates of different sectors of Taiwan in 1990 are shown in Table 4. The three main sectors with the highest CO₂ emissions in 2001 are the industrial sector, which accounted for 57.97% of the total emissions, the transportation sector, with 20.04% of the total emissions, and the industrial sector, with 18.63% of the total emissions. The emissions derived from energy consumption in Taiwan for the period 1990-2009. Basically, the emission rate has been increasing linearly since 1990; the expected goals were realized, the overall effect still needs to be improved; (4) due to policies and greenhouse gas emission baseline investigation and verification systems, though the improvement of energy productivity was obstructed; (3) with respect to energy use failed to be implemented effectively, the industrial energy-saving inducement was reduced, and greenhouse gas emissions of the other sectors all increased, the carbon emission ratios of the sectors other than the energy sector decreased.

| Year | Own Use | Industrial | Transportation | Agricultural | Service | Residential | Total |
|------|---------|------------|----------------|-------------|---------|-------------|-------|
| 1990 | 128,220 | 35,197 | 12,835 | 33,390 | 50,705 | 50,705 | 261,248 |
| 1991 | 137,626 | 35,947 | 12,835 | 33,390 | 50,705 | 50,705 | 261,248 |
| 1992 | 145,669 | 35,947 | 12,835 | 33,390 | 50,705 | 50,705 | 261,248 |
| 1993 | 153,176 | 35,947 | 12,835 | 33,390 | 50,705 | 50,705 | 261,248 |
| 1994 | 161,624 | 35,947 | 12,835 | 33,390 | 50,705 | 50,705 | 261,248 |
| 1995 | 169,216 | 35,947 | 12,835 | 33,390 | 50,705 | 50,705 | 261,248 |
| 1996 | 174,024 | 35,947 | 12,835 | 33,390 | 50,705 | 50,705 | 261,248 |
| 1997 | 178,624 | 35,947 | 12,835 | 33,390 | 50,705 | 50,705 | 261,248 |

The Kyoto Protocol was signed in 1997, and when the Kyoto Protocol went into effect in 2000, the emission rate increased linearly; the economic development trend in Taiwan of recent years shows the structural changes of the various industries in Taiwan. The tertiary industry has increased continuously, rising to 68% in 2008, whereas the proportion of the industrial sector decreased year after year, uniting for only 31% of gross product of Taiwan in 2008, whereas the proportion of the service industry has increased continuously, rising to 68% in 2008.
2.2 Energy consumption structure by sectors

Energy-intensive industries in the sectoral structure of the manufacturing industry still occupy an important position: energy-intensive industries have a high industry correlation effect, and support the development of other middle and downstream knowledge-intensive industries; they represent a stable raw material supply source for various industries, so they profoundly influence the development of Taiwan’s industries. For example, the industrial sector still accounted for 52.5% of energy consumption in 2009. The energy consumption of the industrial sector was 23,145,782 Kt oil equivalents in 1990, and 59,350,964 Kt oil equivalents in 2009, an increase of 256% times. The energy consumption of energy-intensive industries was 14,305,778 Kt oil equivalents in 1990, and 41,040,183 Kt oil equivalents in 2009, an increase of 286%.

The achievement of voluntary greenhouse gas reduction in energy-intensive industries with assistance of the government has been outstanding in recent years. The six major energy-intensive industries jointly signed a greenhouse gas reduction protocol in 2005, expecting to reduce 4.02 million MT CO$_2$e between 2004 and 2008. The accumulated reduction performance was 3.806 million MT CO$_2$e between 2004 and 2007, or 1.1% of total emissions.

Over the past 10 years national energy intensity has edged down from 9.43 to 8.82 liters of oil equivalent (LOE) per NT$1000. This shows that the efforts on various fronts to conserve energy have reaped results. But because energy-intensive industries (including petrochemicals, steel, textiles and paper) have continued to expand, their 23% growth in energy intensity from 2000 to 2009 has offset improved efficiency in other sectors. The figure 4, 5 and 6 depict the energy consumption by different sectors.

### Table 3. The fuel combustion CO$_2$ emissions of different sectors of Taiwan unit: kiloton CO$_2$ %

| Year | Energy Sector Own Use | Industrial | Transportation | Agricultural | Service | Residential | Total |
|------|----------------------|------------|----------------|--------------|---------|-------------|-------|
| 2002 | 138,911              | 60.97      | 43,755         | 19.20        | 34,197  | 15.01       | 2,434 | 1.07 | 3,458 | 1.52 | 5,081 | 2.23 | 227,836 | 100 |
| 2003 | 149,175              | 62.89      | 42,247         | 17.81        | 34,164  | 14.40       | 2,783 | 1.17 | 3,852 | 1.62 | 4,992 | 2.10 | 237,213 | 100 |
| 2004 | 155,211              | 63.27      | 42,554         | 17.35        | 35,501  | 14.47       | 2,947 | 1.20 | 3,989 | 1.63 | 5,101 | 2.08 | 245,303 | 100 |
| 2005 | 161,983              | 64.36      | 41,335         | 16.42        | 36,478  | 14.49       | 2,600 | 1.03 | 4,100 | 1.63 | 5,203 | 2.07 | 251,699 | 100 |
| 2006 | 169,404              | 65.34      | 42,655         | 16.45        | 36,406  | 14.04       | 1,630 | 0.63 | 4,125 | 1.59 | 5,046 | 1.95 | 259,265 | 100 |
| 2007 | 173,047              | 65.85      | 44,442         | 16.91        | 35,071  | 13.35       | 1,080 | 0.41 | 4,067 | 1.55 | 5,080 | 1.93 | 262,787 | 100 |
| 2008 | 167,410              | 66.42      | 41,086         | 16.30        | 33,103  | 13.13       | 1,356 | 0.54 | 4,090 | 1.62 | 4,997 | 1.98 | 252,042 | 100 |
| 2009 | 158,011              | 65.94      | 38,093         | 15.90        | 33,447  | 13.96       | 994  | 0.41 | 4,112 | 1.72 | 4,957 | 2.07 | 239,615 | 100 |

Source: Environmental Protection Administration; Council of Agriculture; Bureau of Energy; Bureau of Industry, ROC
Kt*: Kiloton

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Over the past 10 years national energy intensity has edged down from 9.43 to 8.82 liters of oil equivalent (LOE) per NT$1000. This shows that the efforts on various fronts to conserve energy have reaped results. But because energy intensive industries (including petrochemicals, steel, textiles and paper) have continued to expand, their 23% growth in energy intensity from 2000 to 2009 has offset improved efficiency in other sectors. The figure 4, 5 and 6 depict the energy consumption by different sectors.

![Figure 4: The fuel combustion CO2 emission of different sectors of Taiwan](https://www.intechopen.com)
3. Current problems in various sectors of Taiwan

International reduction strategies and high oil prices promote energy saving and carbon reduction. A number of advanced countries have developed national reduction strategies based on international commitments since the Kyoto Protocol went into effect. A consensus on reducing at least fifty percent of global greenhouse gas emissions by 2050 was reached at the G8 Summit in July 2008. The international consensus on carbon reduction applies
pressure on Taiwan. Taiwan shares the responsibility for reducing emissions and has taken position actions in this regard. Furthermore, international oil prices have risen sharply in recent years, and high oil prices have become a long-term trend, making energy efficiency an indicator of inter-industry competitive power. The implementation of measures for energy saving and carbon reduction has come under internal and external pressures.

3.1 Energy efficiency improvement problems in the industrial sector
- The industrial sector has the maximum energy consumption ratio.
- Since the industrial sector has promoted energy saving for a long time, the energy-saving potential of existing equipment is limited.
- The inducement of a voluntary energy conservation agreement is not enough as energy prices are low.
- There are no energy conservation standards of design, construction and the use of business sites and factory buildings.
- There have been no energy efficiency standards of important power equipment (e.g., air compressors, fans, pumps, et al.).

3.2 Energy efficiency improvement problems in the transportation sector
- Transportation demand increases continuously with economic development and population growth.
- Green energy is not yet popular; fuel alternatives are limited.
- Low-carbon transport is difficult to implement in the short term due to high costs.
- The external cost of private transport has not been sufficiently disclosed; the inducement of cost differentials between private transport and public transport remain insufficient.
- The quantity and quality of public transport service still need to be improved.

3.3 Energy efficiency improvement problems in residential and commercial sectors
- Power demand increases continuously with economic development and population growth.
- The energy efficiency of electrical equipment is not clearly indicated.
- The standby power of electrical equipment lacks effective management.
- There is no inducement to invest in green buildings.
- Making energy conservation improvements in old buildings is lacking in incentives.
- No energy conservation standards exist for the design and construction of new buildings.
- High costs make it difficult to equip buildings with renewable energy.
- Inducements for buying energy-saving building materials and appliances still need to be increased.
- The low recovery rate of building materials influences source-reduction performance.

4. Current policy measures in Taiwan
The Executive Yuan of Taiwan adopted the “Sustainable Energy Policy Convention” on June 5, 2008 to construct a “high efficiency”, “high value”, “low emission” and “low dependence” energy consumption pattern and supply system, so as to realize the three-win vision of
energy, environmental protection and economy. The specific measures cover energy saving and carbon reduction of the five major sectors of energy, industry, transportation, environment and life. Regulations and relevant supporting mechanisms have been completed in the hope of attaining the following goals of energy conservation: an increase in the energy efficiency by more than 2% annually to reduce energy use in 2015 by more than 20% from levels in 2005. In terms of carbon reduction the goal is to reduce CO₂ emissions in Taiwan between 2016 and 2020 to levels in 2008, and reduce the levels of emissions in 2025 to those in 2000.

Generally speaking, the energy supply side works on “clean sources” and the energy consumption side works to “reduce expenditures.” Energy conversion efficiency must be stressed on the energy conversion side, such as the generating efficiency of power plants and the oil refining efficiency of oil refineries. Higher energy conversion efficiency means “cleaner sources.”

Regarding the energy supply side, Taiwan’s primary energy supplies are derived mainly from coal, crude oil, natural gas, nuclear energy, and renewable energy. Coal and crude oil are high-carbon energy, whereas natural gas, nuclear energy and renewable energy are classified as low-carbon energy. In terms of clean sources, the ratio of low-carbon energy in the overall primary energy structure must be increased.

Secondly, energy conversion efficiency must be increased, such as increasing the generating efficiency of power plants. High efficiency means using the least primary energy (e.g., coal) to yield the most end-use energy (e.g., electricity) for consumption. Increasing energy conversion efficiency is one of means of developing “clean sources.”

| Item                        | Energy saving and carbon reduction mode | Sector                      | Measures                                                                 |
|-----------------------------|----------------------------------------|-----------------------------|--------------------------------------------------------------------------|
| Energy supply               | Clean sources                          | Energy sector               | Adjust energy structure, adopt low-carbon energy (nuclear energy, renewable energy) |
|                             |                                        | Industrial sector           | Adjust industrial structure, encourage low-carbon industries             |
| Energy conversion           | Clean sources                          | Energy sector               | Increase generating efficiency of power plants                           |
| Energy consumption          | Reduce expenditure                     | Industrial sector           | Increase energy utilization efficiency, conserve energy                  |
|                             |                                        | Transportation sector       | Increase energy utilization efficiency, conserve energy                  |
|                             |                                        | Residential and commercial sector | Conserve energy (e.g., ten major measures for energy saving and carbon reduction) |
|                             |                                        | Government sector           | Carbon neutral                                                            |
|                             |                                        | The public                  | Nationwide energy saving and carbon reduction movement                   |

Table 4. Existing circumstances of the division of work, measures and promotion of energy saving and carbon reduction in Taiwan
Energy consumption is closely related to the daily lives of ordinary people (consumers); it is the starting point from which the general public practices energy saving and carbon reduction, which are the ultimate goals of the “ten major measures for energy saving and carbon reduction” promoted by the government. We usually divide energy consumption into sectors such as transportation, and residential, commercial and industrial sectors for convenience in applying data statistics and policy implementation. This part of energy saving and carbon reduction starts with “reducing expenditures.”

The following table summarizes initiatives in carbon reduction and the implementation of primary measures with respect to energy supply, conversion and consumption.

### 4.1 For “clean sources,” reconstruct the energy structure and improve efficiency

- Develop carbon-free renewable energy sources; make effective use of renewable energy development potential, in order to accounts for more than 8% of the generating system by 2025. The total installed capacity of renewable energy is 3.328 million kW, equivalent to 11.1 billion kWh per year, which can reduce about 6.9 million MT CO₂ emissions. The installed capacity of renewable energy is planned to be 8.45 million kW in 2025, accounting for 15.1% of total installed capacity.
  1. Photovoltaic power generation: promote the installation of solar roofs, solar campus, remote off-island emergency disaster prevention, revitalizing the economy; the total installed capacity is 22.4 thousand kW, equivalent to generating 26.91 million kWh per year, so that about 16.7 thousand MT of CO₂ emissions can be reduced.
  2. Wind power generation: the total installed capacity of wind power generation is 518.7 thousand kW (268 units), and the annual power generation is about 1.296 billion kWh, which can serve about 324.2 thousand households and reduce 807.9 thousand MT of CO₂ emissions.
  3. Biodiesel: the estimated annual reduction of CO₂ emission is about 330 thousand MT, equivalent to the CO₂ volume absorbed by about 343 Daan Forest Parks; as for the industrial benefit, there were 10 qualified biodiesel plants up to December 2010, the total annual output is 130 thousand KL, the accumulated industrial investment of about 1 billion NTD has been driven, when 2% biodiesel is added in, the estimated annual output value is about 3 billion NTD.

- Reduce the carbon footprint of electric power: in order to reduce the CO₂ emissions resulting from the power consumption of other sectors, low-carbon and non-carbon energy generation shall be a primary objective in short-term planning; the efficiency of existing power plants shall be increased in medium-term planning, and the structure of power-generating resources shall be adjusted in long-term planning.

- Improve the overall energy efficiency and energy conservation: energy use was 8.47 liter oil equivalent/thousand NTD in 2010; it was reduced by 3.97% (8.82 liter oil equivalent/thousand NTD) from 2009. Taiwan l energy conservation goal to increase its energy efficiency by more than 2% annually has been attained.
4.2 “Reducing expenditure” by promoting substantial energy savings and carbon reduction measures in all sectors

4.2.1 Industrial sector

- Strengthen energy management and increase energy efficiency: according to the “Energy Management Law” passed on July 8, 2009, large-scale productive investment production plans shall be managed in advance, and a mandatory energy label system shall be established.
- Expand energy conservation services: a “comprehensive energy conservation center” is to be established; provide 4,712 energy users with energy conservation guidelines between 2009 and 2012; assist in industrial energy conservation of 525 thousand Kt. oil equivalents (equivalent to reducing energy costs by 10.7 billion NTD).
- Promote voluntary energy conservation in the service industry: a convention at which telecom and communication producers and 3C household appliance groups signed a voluntary energy conservation agreement was held on August 9, 2010. The goal of energy conservation through 2012 is set at 5%. Estimated energy conservation potential is 50 million kWh. Convenience stores, hypermarkets, hospitals, hotels, department stores, supermarkets, shopping centers, telecom and communication producers and 3C household appliance groups of ten major industries (102 group enterprises) signed a voluntary energy conservation agreement effective between 2006 and 2010; the signed groups reduced energy use by 11.9% on average from 2006 to 2009, for a total reduction of 717 million kWh.
- Urge the industrial sector to develop high-added value and low-energy consumption; reduce the carbon emission intensity of unit output value by more than 30% by 2025.
- Check and allocate enterprise carbon credits; assign responsibility for carbon reduction; urge enterprises to promote production and sales systems for energy saving and carbon reduction. Promote voluntary greenhouse gas reduction plans in the energy industry: 33 plants, including Tunghsiao Power Plant of Taiwan Power Co., Ltd. were given assistance in devising voluntary reduction plans up to December 2010; 20 plants were given assistance in gaining approval of their reduction plan designs; 17 plants were given assistance with “ISO 14064-2” verification. Total reduction was more than 6.48 million MT CO2 equivalents, which shall be used as reference for emission offset or trading of total greenhouse gas control and protecting the preliminary efforts of firms.
4.2.1 Industrial sector
and carbon reduction measures in all sectors

- Help small and medium-sized enterprises strengthen their ability to save energy and reduce carbon emissions. Establish inducement measures and management systems and encourage clean production. Energy-saving technology service was provided to 997 enterprises through December 2010. The energy conservation potential of 151.8 thousand Kl. oil equivalent was explored; it was estimated that 80 thousand Kl. oil equivalent could be conserved.
- Encourage popularizing energy saving and carbon reduction and renewable energy and other green energy industries; create a new energy economy.

4.2.2 Transportation sector

- Build seamless urban public transport services; strengthen the accessibility of township public transport systems; take care of remote places.
- Provide real-time traffic information and public transport change information; improve the convenience of public transport and strengthen traffic control functions.
- Build a bicycle path network all over Taiwan; improve the safety, connectivity and continuity of bicycle paths.
- Popularize urban bicycle path networks; provide bicycle parking facilities; establish bicycle rental and riding control systems and facilities; strengthen systematic measures for change in public transport terminal yards.
- Strengthen transport management measures; consider the social cost of private transport in a reasonable manner.
- Internalize the external cost of private transport; promote levying a fuel tax on oil; enlarge the gap of public transport costs.
- Promote ride sharing and safety mechanisms.
- Increase the efficiency level of new cars for private transport by 25% in 2015.
- Promote the reasonable use of biomass fuel in automobiles.
- Promote low-carbon electric vehicles.

Residential and commercial sectors

- Promote mandatory energy efficiency grade labeling: since the announcement of regulations on air-conditioners, refrigerators, cars and motorcycles for energy efficiency grade labeling on July 1, 2010, energy efficiency grade labeling shall be pasted or placed on all such items for sale. Increase the energy efficiency of various power consuming appliances by 10%~70% by 2011, and raise the standard in 2015; popularize high-efficiency products.
- Promote a revolution in energy-saving lighting; promote the "LED traffic signal lamp energy conservation project plan": 17 county and city governments including New Taipei City were given assistance in replacing 135,238 LED traffic signal lamps in 2009 and 2010; 3 municipalities directly under the central government including Taipei City and 11 counties and cities including Keelung City replaced all their signal lamps by 2010. It is estimated that 91% of the 700 thousand traffic signal lamps in Taiwan have been replaced.
- Accelerate the promotion of green buildings; establish systems to encourage their design; assist in providing existing buildings with green building features; provide incentives and rewards.
- Stipulate energy conservation standards of shell energy consumption, air conditioning and lighting systems in the design or construction of new buildings.
- Accelerate the promotion of voluntary agreement of large congregated residential houses; meet the energy conservation potential of the residential sector.
- Provide financial and tax incentives for buying and using green buildings, green building materials and recycled building materials.
- The regulations of buildings shall specify that buildings above a certain scale shall be equipped with renewable energy consuming facilities to increase the use ratio of renewable energy in buildings.

4.2.3 Government sector

- Promote energy conservation in government offices and schools: implement “overall energy saving and carbon reduction measures for government offices and schools”; set negative growth targets for annual power and oil consumption; the overall reduction for 2015 should be 7% of the 2007 figure; help government offices and schools introduce an “energy technology service industry” to improve energy conservation. The energy-saving technology service was implemented in 168 government offices and schools from January to December 2010; the energy potential of 23 thousand Kl. oil equivalents was conserved.
- There shall be a “carbon neutral” concept in policy planning; carbon is to be controlled by putting into practice precautionary, pre-warning and screening principles.

4.2.4 The public

- Promote a nationwide energy saving and carbon reduction movement; encourage the public to “reduce 1 kg carbon footprint per day.”
- Promote the policy “discounts for electricity costs for encouraging energy-saving measures”: 6,452 households received discounts for electricity costs from July 2008 to January 2011; a total of 10.54 billion kWh was conserved; it was 44% higher than the total power consumption (7.3 billion kWh) of all the households in Taipei City in 2009. The total electric cost deduction was 17.52 billion NTD; CO2 reduction was about 6.70 million MT. The “county-city electricity saving competition” was carried out three times in 2010 since its implementation on July 1, 2010. The first-place winners of the three competitions were Hsinchu City, Chiayi City and Kaohsiung County, respectively. The electricity saving rates was 4.48%, 7.16% and 4.58%, respectively.

5. Taxation tools for energy saving and carbon reduction in Taiwan

There have never been taxes such as a “carbon tax”, an “energy tax” or a “green tax” in Taiwan. Taxes related to the environment or energy sources have been levied for the existing policy purposes of energy conservation, environmental protection, maintaining health and rectifying external effects, including an energy tax, a transportation tax, a pollution tax and a tax on resources.
Natural resources may be put in production for economic development, or the manufacturing process may produce wastes or emissions; if the waste of resources and the creation of emissions are not suppressed properly, environmental resources will be exhausted and the environmental quality will deteriorate. For a sustainable utilization of environmental resources, the government can adopt direct administrative control measures for environmental protection and resource management and utilization, and can use economic tools such as an environmental tax, environmental fees, tradable emission permits or quotas, a deposit system and environmental subsidies for environmental protection, so as to carry out the principle by which the environmental media or resource users, or polluters are required to pay fees.

Since the use of environmental taxes tends to be diversified, such taxes benefit both the environment and economy, making it an important policy tool. Acquiring environmental tax data and making comparisons with other countries are feasible steps to take. International organizations are currently discussing the issue of environmental taxes. For example, the OECD makes use of basic statistics; the EU has a statistical handbook; the EU and SEEA have 2003 manuals which define environmental taxes as taxes levied on physical units which have been proved harmful to the environment in a statistical structure. The definition of “tax” is similar to the concept of national income statistics in referring to compulsory and voluntary payments to individual governments.

Environmental tax statistics are divided into four major types in the world, including an energy tax, a transportation tax, a pollution tax and a tax on resources. An energy tax base includes the energy products of transportation and fixed use. A transportation tax is based on the possession and use of motorized vehicles. A pollution tax aims at the discharge of air and water and the management of solid waste and noise. A resources tax aims at water extraction, sandstone, primary raw materials and the exploitation of forest resources; it excludes natural gas and petroleum exploitation (which is regarded as resource rent instead of tax).

Statistical items of the environmental tax in Taiwan include an energy tax, a transportation tax and a pollution tax, but no resources tax. The energy tax includes an energy tariff, oil and gas excise tax and a petroleum fund of energy resources. The transportation tax includes a transport tariff, a vehicle excise tax, a vehicle license tax and a charge for use of automobile fuel. The pollution tax includes air pollution prevention and control fees, soil and ground water contamination regulation fees and recovery and treatment fees.

The present environment-related tax items, competent authorities, sources of law, taxpayers and coverage of taxation in Taiwan are shown in Table 5.

Table 6 illustrates the environmental tax rates in Taiwan. Table 7 shows the environmental tax revenues and composition of Taiwan; it also shows that tax revenues totaled 227.89 billion NTD in 2009, an increase of 0.2% from 2008. The transportation tax of 132.12 billion NTD accounted for 58.0%; the energy tax of 84.86 billion NTD accounted for 37.2% for a combined total of 95.2%. The pollution tax was 10.9 NTD, accounting for 4.8%. The energy tax was 84.86 billion NTD in 2009, an increase of 9.8% from 2008; the oil gas excise tax of 84.29 billion NTD accounted for 99% of the energy tax. The petroleum fund was
330 million NTD, accounting for only 0.4%. In addition, imported energy decreased greatly as a result of the economic recession. Revenue from the petroleum tariff decreased to 230 million NTD, a sharp decrease of more than 75%; its proportion decreased to 0.3%.

Revenue from the transportation tax was 132.12 billion NTD, a decrease of 4.4% from 2008. Revenue from the vehicle license tax was 53.05 billion NTD, accounting for 40.2% of the transportation tax. Automobile fuel fees totaled 43.24 billion NTD, accounting for 32.7%; in addition, the vehicle excise tax decreased 17.6% from 2008 as a result of poor motorcycle sales in Taiwan; its proportion decreased to 21.0%.

The pollution tax generated revenues of 10.9 billion NTD in 2009, a decrease of 9.7% from 2008. The “Recycling, Clearance, and Disposal Fees” resulted in 6.01 billion NTD, accounting for 55.1% of pollution tax revenues. The “Air Pollution Control Fee” in Pollution Control accounted for 39.3%, and the “Soil and Groundwater Pollution Remediation Fee” oil and Groundwater accounted for only 5.6%.
| Tax item                  | Tariff                        | Excise tax                      | Vehicle's Fuel Charge | Air pollution fee | Soil pollution fee |
|--------------------------|-------------------------------|---------------------------------|-----------------------|-------------------|-------------------|
| Competent authority      | Ministry of Finance           | Ministry of Finance             | Ministry of Transportation and Communications | Environmental Protection Administration | Environmental Protection Administration |
| Source of law            | Customs Law                   | Excise Tax Regulations          | Highway Law           | Air Pollution Control Law | Soil and Groundwater Pollution Remediation |
| Taxpayer and coverage of taxation | Imported dutiable goods shall be levied on according to tariff regulations. | Taiwan made or imported dutiable goods shall be levied on according to excise tax regulations. | All vehicles on highways or in urban area, excluding the tax-exempt vehicles specified in Article 4 of Highway Law. | Mobile pollution sources: the distributors or users are levied on according to the variety and quantity of discharged air pollutants, and the distributors or importers are levied on according to the composition and quantity of oil fuels. | Makers and importers of specified chemical substances are levied on according to the output quantity and input quantity. |

Source: Ministry of Finance, Directorate General of Budget, Accounting and Statistics, Executive Yuan, R.O.C. (2011).

Table 5. Taiwan’s Environment-related Taxes
Taiwan’s taxation policies for various environment-related taxes in the future: The “Regulation for Energy Tax (draft)” is being scheduled for legislative review.

The fundamental aspects of the Energy Tax are as follow:

- Implement an energy tax to maintain a financial balance.
- According to the conclusions of the Tax Reform Committee, Executive Yuan, the implementation of a green tax system will integrate the present oil gas excise tax, automobile fuel fee and petroleum fund. The increased tax revenues after implementation will be used to subsidize low-income households and public transport first; untimely items of excise tax, stamp duty and amusement tax systems will be reformed to reduce their impact on the public.
- As the energy tax system will exert a significant influence on industry and the economy, the Ministry of Finance will study the influence of the energy tax on the economy, industry and the environment as well as the opinions of all circles of society before drafting and planning the tax system, which will be implemented at a proper time.
### Table 6: Energy-Related Tax Rates

| Item | Import Tariff | Trade Promotion Service Fee | Excise Tax | Petroleum Fund | Soil and Groundwater Pollution Remediation Fee |
|------|---------------|-----------------------------|------------|----------------|-----------------------------------------------|
|      | Column I      | Column II                  | Column III |                |                                               |
| Crude Oil | 0%           | 0%                          | 2.50%      | 0.04%          | (Free)                                        |
|        |               |                             |            |                | 109 NT $ /KL                                   |
|        |               |                             |            |                | 0NT $ /T                                       |
| Fuel Oil | 5% (2.5%)     | 0%                         | 5%         | 0.04%          | 0.11NT $ /L                                   |
|        |               |                             |            |                | 137 NT $ /KL                                   |
|        |               |                             |            |                | 12NT $ /T                                      |
| Kerosene | 0%           | 0%                          | 15%        | 0.04%          | 4.25NT $ /L                                   |
|        |               |                             |            |                | 133NT $ /KL                                    |
|        |               |                             |            |                | 0NT $ /T                                       |
| Kerosene Type Jet Fuel | 0% | 0% | 15% | 0.04% | 0.61NT $ /L |
|        |               |                             |            |                | 133NT $ /KL                                    |
|        |               |                             |            |                | 0NT $ /T                                       |
| LPG                        | 0% | 0% | 2.50% | 0.04% | 0.69NT $ /KG |
|        |               |                             |            |                | 151NT $ /T (Butane)12NT $ /T                   |
| Gasoline                  | 0% | 0% | 15%  | 0.04% | 6.83 NT $ /L |
|        |               |                             |            |                | 169 NT $ /KL                                   |
|        |               |                             |            |                | 22NT $ /T                                      |
| Diesel Oil                | 0% | 0% | 15%  | 0.04% | 3.99NT $ /L |
|        |               |                             |            |                | 144NT $ /KL                                    |
|        |               |                             |            |                | 22NT $ /T                                      |
| Natural Gas               | 0% | 0% | 7.50% | 0.04% | 0         |
|        |               |                             |            |                | 0                                               |
|        |               |                             |            |                | 0                                               |
| Steam Coal                | 0% | 0% | 0%   | 0.04% | 0         |
|        |               |                             |            |                | 0                                               |
|        |               |                             |            |                | 0                                               |
| Coking Coal               | 0% | 0% | 0%   | 0.04% | 0         |
|        |               |                             |            |                | 0                                               |
|        |               |                             |            |                | 0                                               |
| Electricity               | -   | -   | -    | -   | 0         |
|        |               |                             |            |                | 0                                               |
|        |               |                             |            |                | 0                                               |

Source: Ministry of Finance, Directorate General of Budget, Accounting and Statistics, Executive Yuan, R.O.C (2011).

Note: The import tariff rate is divided into three columns. The first column applies to goods imported from WTO members or from countries or areas that have reciprocal agreements with the Republic of China. The second column applies to specified goods imported from specific underdeveloped or developing countries or areas, or from countries or areas which have signed a Free Trade Agreement with the Republic of China. When the rates in the first and second column are not applicable, the rates in the third column shall apply.

Table 6. Energy-Related Tax Rates
## Table 7. Energy-related Tax Revenues and Composition

| Year       | 2007     |   | 2008     |   | 2009     |   |
|------------|----------|---|----------|---|----------|---|
|            | amount   | % | amount   | % | amount   | % |
| Total      | 253,801  | 100| 227,517  | 100| 227,886  | 100|
| Energy Tax | 89,324   | 35.19%| 77,290   | 33.97%| 84,859   | 37.24%|
| Import Tariff | 910   | 0.36%| 964   | 0.42%| 233   | 0.10%|
| Oil Gas Excise Tax | 87,560 | 34.50%| 75,735   | 33.29%| 84,293   | 36.99%|
| Petroleum Fund | 854    | 0.34%| 591    | 0.26%| 333    | 0.15%|
| Transportation Tax | 152,219| 59.98%| 138,157 | 60.72%| 132,124 | 57.98%|
| Import Tariff | 10,816 | 4.26%| 7,419 | 3.26%| 8,091 | 3.55%|
| Vehicle Excise Tax | 43,953 | 17.32%| 33,677 | 14.80%| 27,741 | 12.17%|
| Vehicle License Tax | 53,271 | 20.99%| 53,255 | 23.41%| 53,050 | 23.28%|
| Vehicle Fuel Charge | 44,179 | 17.41%| 43,806 | 19.25%| 43,242 | 18.98%|
| pollution tax | 12,258 | 4.83%| 12,070 | 5.31%| 10,903 | 4.78%|
| Air Pollution Control Fee | 4,810 | 1.90%| 4,946 | 2.17%| 4,282 | 1.88%|
| Soil and GW Pollution RD Fee | 711 | 0.28%| 575 | 0.25%| 612 | 0.27%|
| Recycling, Clearance, Disposal | 6,737 | 2.65%| 6,549 | 2.88%| 6,009 | 2.64%|

Source: Ministry of Finance, Directorate General of Budget, Accounting and Statistics, Executive Yuan, R.O.C (2011).
6. Conclusion

Taiwan is encountering the global environmental crises related to global warming and faces continuing challenges from the environmental deterioration stemming from economic development. Taiwan is deficient in conventional energy resources and highly dependent on energy imports, with nearly 90% of its greenhouse gas (GHG) emissions coming from carbon dioxide emitted from energy use. The annual growth of GHG emissions has been slowing in recent years, with negative growth reported for the first time in 2008. Taiwan is currently not a signatory to the United Nations Framework Convention on Climate Change; however, as a member of the global village Taiwan has committed itself to sharing the obligations of common but differential responsibility in accordance with the basic principles of the UNFCCC. In order to maintain national competitiveness and limit the consumption of high-priced energy, the government will continue to implement energy conservation and carbon reduction measures for national sustainable development.

But if we truly want to reshape the nation’s industrial structure through imposed controls, effective means should include both the imposition of energy taxes and the passing of a Greenhouse Gas Emissions Reduction Act. Energy conservation and carbon reduction in Taiwan will never be just a slogan, but a new lifestyle in action.

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1. Introduction

Facing climate change, energy dependency and energy security and other significant environmental challenges, many countries try to seek environmental sustainability, promote a green new deal, and develop renewable energy. IPCC (2011) found that building a low-carbon city, developing low-carbon industry and promoting low-carbon life are the major means for most countries to achieve a low-carbon society.

The major renewable energy sources include solar energy, wind power, biomass, geothermal, hydro power et al. REN21 (2011) Renewables 2011 Global Status Report indicated that in 2009 global renewable energy sources supplied 16% of global final energy consumption. In 2011 additional investments of renewable energy in the world were US$211 billion and the top 5 new capacity investment countries were China, Germany, the United States, Italy, and Brazil, respectively. In terms of new investment in types of energy, China was among the top-ranking countries in wind power and solar heat; Germany was at the top in solar photovoltaic and biodiesel production sources, and the United States was tops in ethanol production.

In 2010 the worldwide total renewable energy capacity was 1,320 gigawatts (GW), and the largest 3 types of renewable energy capacity (REC) were hydro power 1,010 GW, wind power, 198GW and the energy PV 40GW. The top 5 countries of REC were China, the United States, Canada, Brazil, and Germany/India. China was ranked at the top in capacity of wind power and solar heat; the United States was ranked first in biomass and geothermal power, and Germany was number one in solar PV (REN21 2011).

In recent years the two most important renewable energy tools in the European Union (EU) have been the Feed-in Tariff (FIT) and the Quota/TGC (a quota regulation in combination with a tradable green certificate). Twenty out of twenty-seven EU member nations are using FIT as their main renewable energy tool (Klein, et al., 2008). Table 1 reveals that no matter the extent of economic growth or national income distribution, all countries in the world promote an FIT policy to deal with the impact of environmental change (REN21, 2011).

Taiwan is located in a sub-tropical area with abundant sunshine, surrounded by seas with strong wind power and ample currents; therefore, the island is suitable for developing renewable energy. Taiwan has a relative low energy demand and a large proportion of energy comes from coal power, a high carbon source, which is not sustainable. Therefore, in order to improve energy efficiency and security, low-carbon development is a major goal for Taiwan. Starting from 2000, Taiwan has implemented a number of energy policies, such as the Restriction on the Industrial Energy Consumption and the Restriction on Energy Consumption in Major Industries, as well as other energy conservation and emission reduction measures. To promote low-carbon energy development, the Taiwanese government has invested in renewable energy projects. The government has also implemented a Feed-in Tariff system to encourage renewable energy development. This system provides financial incentives for renewable energy projects, which helps to promote the development of renewable energy in Taiwan.

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Taiwan, a typical small Asian country with few energy resources, is well known for its high-tech industry in the last 20 years. However, as a member of the global village, Taiwan feels the responsibility to reduce carbon emissions. The book tells you how Taiwan transforms itself from a high-tech island to become a low carbon island. The book addresses Taiwan’s low-carbon developmental policies of the past 10 years, applies an econometric approach to estimate Taiwan’s sector department CO2 emissions, shows how environmental change affects the economic growth of Taiwan, and provides two successful examples of low-carbon pilot regions in Taiwan. Stephen Shen, the Minister of the Environment Protection Agency of Taiwan, believes that the book arrives at the right time, because this is the time to educate the people of Taiwan about the necessary action for achieving a low carbon society.

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