

## The Eight Indicators

### ►Indicator 1: CO<sub>2</sub> emissions from the energy sector (per capita)

Emissions of CO<sub>2</sub> evolved roughly parallelly to the total energy consumption in the last ten years. The ratio between CO<sub>2</sub> and total energy consumption is 2.14 kg CO<sub>2</sub> /Toe in 1990, 2.31 in 1995, and 2.36 in 1997.

It is interesting to note that total energy consumption in 1981 is 28,517.6 Mtoe. The corresponding CO<sub>2</sub> /energy ratio is 0.965, less than 1/2 of that in the 90's. The reason for such big increase in CO<sub>2</sub> emissions is the fuel change. From 1981 to 1999, the consumption of coal increased by factor of 8.5, while oil increased 2.3 times.

Since 1981, there are 4 nuclear commercial reactors, with a total capacity of 3872 MW. Although many people strongly suggest that nuclear energy should be included as an important alternative to reduce greenhouse gases emissions, in Taiwan's experience, nuclear energy does not help in reducing greenhouse gas emissions. Some claim that the huge output from nuclear power promotes energy consumption and reduces the need for energy conservation.

All indicators have similar formula, as  $I = (X - Y) / Z$ . Where I is the indicator; X the value of certain parameters; Y is the reference toward sustainability; and Z is a segment which goes from 0 to 1. For the first indicator, the assigned numbers for Y, Z are 339, and 791 kgC per capita. These correspond to 30% and 70% of the 1990 world average CO<sub>2</sub> emissions in terms of kgC. The higher is the number means the farther away it is from sustainability. The corresponding numbers in kgCO<sub>2</sub> are 1243 (30%), and 2900 (70%).

**Table 1. Past Figures and Future Projection CO<sub>2</sub> Emissions in Taiwan**

Year	Total CO <sub>2</sub> (Mtons CO <sub>2</sub> )	CO <sub>2</sub> per capita (tons CO <sub>2</sub> )	Indicator 1
1981	27.51	1.52	0.09
1990	112.7	5.54	1.51
1995	162.5	7.63	2.08
1997	184.5	8.50	2.32
2000	223.0	10.1	2.75
2005	261.6	11.2	3.05
2010	294.8	12.1	3.30

**Source: Energy Committee, Ministry of Economic Affairs, Taiwan**

Numbers provided in the table above indicate a drastic change in the eighties in energy use. The trend becomes worse if the government projection materialize.

## ►Indicator 2: Local Air Pollution

The per capita emissions are 15.75 Kg and 23.86 Kg, respectively. These numbers are not particularly high when comparing with OECD countries. The per square kilometer loading for SO<sub>x</sub> and NO<sub>x</sub> are 9.66 tons and 14.17 tons respectively. The latter numbers are much higher than in most OECD countries. The reason for these differences is our high population density. Below please find the list of annual emissions of SO<sub>x</sub> and NO<sub>x</sub> in Taiwan.

Here the indicator is the pollutant ratio between current year and a reference year. The higher the number means that the amount of pollutants are increasing. In this case, indicator in 2000 is slightly less than that of 1992, the reference year. Emissions of SO<sub>x</sub> dropped, but NO<sub>x</sub> increased in similar percentage during this period.

### Indicator 2: Annual overall emission (tons/yr)

Year	SO <sub>x</sub>	NO <sub>x</sub>	Indicator 2
1991	617268	430524	1.1779
1992	487985	407963	1
1993	463410	414499	0.9809
1994	410142	415427	0.9215
1995	445460	646103	1.2760
1996	425033	526077	1.0892
1997	407645	517108	1.0572
1998	387320	496017	1.0053
1999	347100	525746	1.0000
2000	347843	510003	0.9794

Source: Environmental Protection Administration, Taiwan

In this study, year 1992 was chosen as the reference year, since earlier data showed abnormal fluctuations. Quality of these data sets are questionable, for example there is a big jump between NO<sub>x</sub> data of 1994 and 1995.

In 2000, the corresponding indicator for SO<sub>x</sub> is  $(347843/487985)=.7128$ . The corresponding indicator for NO<sub>x</sub> is 1.2501. Combining these two numbers gives the value of 0.9814. Throughout the last decade, little improvement in pollution reduction was achieved. All these ten indicators give the average of  $1.0438 \pm 0.0959$ .

### ▶Indicator 3: Reliable electricity accessibility

close to 100 %

## ►Indicator 4: Investment in clean energy.

Data is not available. Numbers listed here are only the investment by state-owned Taipower company during these years. Total investments by independent power producers are not known. All IPPs are based on fossil fuel and the first one on line was in June 1999. Besides, some of the hydro projects are meant for night pumping to store excess electricity generated from nuclear power plant. The real investment in renewable energy must be lower. The trend will be worse in recent year for the reasons mentioned.

In this indicator, the renewable investment ratio in 1990 was transformed into 1. An investment of 95 % in renewable would correspond to zero in indicator 4. Increase in the investment ratio would reduce the indicator. On the other hand, the larger the indicator is, the less money is invested in renewables.

### Indicator 4: Investment in Clean Energy

Year	% Investment in Renewables	Indicator 4
1990	0.2497	1.000
1995	0.1460	1.148
1997	0.1221	1.148
1999	0.1185	1.187

**Source: Taipower, Private Communication.**

## ►Indicator 5. Energy vulnerability

This indicator is the ratio between the import non-renewable energy and total consumption of non-renewable energy. Due to losses, consumptions are sometimes less than the amount imported. Taiwan is highly dependent on imported energy.

Year	Import of Non-Renewables (MTOE)	Consumption of Non-renewables (MTOE)	Indicator 5
1990	54,759.4	50,710.1	1.080
1991	55,762.1	54,484.6	1.023
1992	60,901.1	56,910.6	1.070
1993	65,608.7	60,854.6	1.078
1994	69,664.3	65,228.9	1.068
1995	76,315.4	68,223.7	1.119
1996	79,998.8	71,602.4	1.117
1997	84,937.4	76,124.2	1.116
1998	88,770.6	80,139.7	1.108
1999	95,698.2	84,025.9	1.139

**Source: Council for Economic Planning and Development, Taiwan**

## ►Indicator 6: Importance of the public sector in energy investments

This indicator is the ten times the ratio between the public investments in non-renewable energy and the GDP. Followings are listed the total investment by Taipower company. As noted earlier, some of the hydroelectric project are meant for storing excess electricity generated from nuclear power plants. If those projects are included, there are higher indicator values.

### Indicator 6. Public investment on Energy

Year	TaiPower Investment in Non-renewables (in M NT)	Taiwan GDP (in M NT)	Indicator 6
1990	27,481	4,307,043	0.064
1995	29,978	7,017,933	0.043
1997	28,361	8,328,780	0.034
1999	27,798	9,312,246	0.030

**Source: Taipower Company, private communicaton.**

## ►Indicator 7: Energy intensity

This indicator considers the consumption of primary energy per unit of GDP. The world average number in 1990, 10.64MJ/USD, is used for comparison. One-tenth the 1990 average, 1.06, were set as the goal for sustainability. The 1990 world average is converted to an indicator 7 of 1, using  $I = (X - 1.06) = 9:58$ . 9.58 is 90% of the 1990 world average. In Taiwan's case, little changed in the nineties.

### Indicator 7. Energy intensity

Year	Twn GDP (in M USD)	Total Energy Consumption (in 10 <sup>3</sup> TJ)	Energy Intensity (MJ/USD)	Indicator 7
1990	160,184.5	2,200,766	13.739	1.323
1991	179,363.3	2,333,559.0	13.010	1.247
1992	212,191.5	2,462,273.8	11.604	1.101
1993	224,257.3	2,611,604.4	11.646	1.105
1994	244,278.1	2,814,295.8	11.521	1.092
1995	264,927.6	2,939,393.2	11.095	1.048
1996	279,611.2	3,082,112.8	11.023	1.040
1997	290,211.5	3,277,435.4	11.293	1.068
1998	267,153.8	3,453,444.3	12.927	1.239
1999	288,698.1	3,601,627.7	12.475	1.192

## ►Indicator 8: Deployment of Renewable Energy

Given the percentage of consumption of renewable energy within the total consumption of primary energy, the world consumption of renewable energy in 1990 is 8.64%. Indicator is set as  $I = x - 0.95 / (-0.8636)$ . In Taiwan's case, there is little improvement in this period.

### Indicator 8. Deployment of Renewable Energy

Year	Total Energy Consumption (MToe)	Hydro-Electric (Mtoe)	Ratio of Renewables (x)	Indicator 8
1990	52,564.40	1854.3	0.0352	1.059
1991	55,736.10	1251.5	0.0224	1.074
1992	58,810.40	1899.8	0.0323	1.063
1993	62,377.10	1522.5	0.0244	1.072
1994	67,218.30	1989.4	0.0295	1.066
1995	70,206.20	1982.5	0.0282	1.067
1996	73,615.00	2012.6	0.0273	1.068
1997	78,280.20	2156	0.0275	1.068
1998	82,484.10	2344.4	0.0284	1.067
1999	86,023.40	1997.5	0.0232	1.073