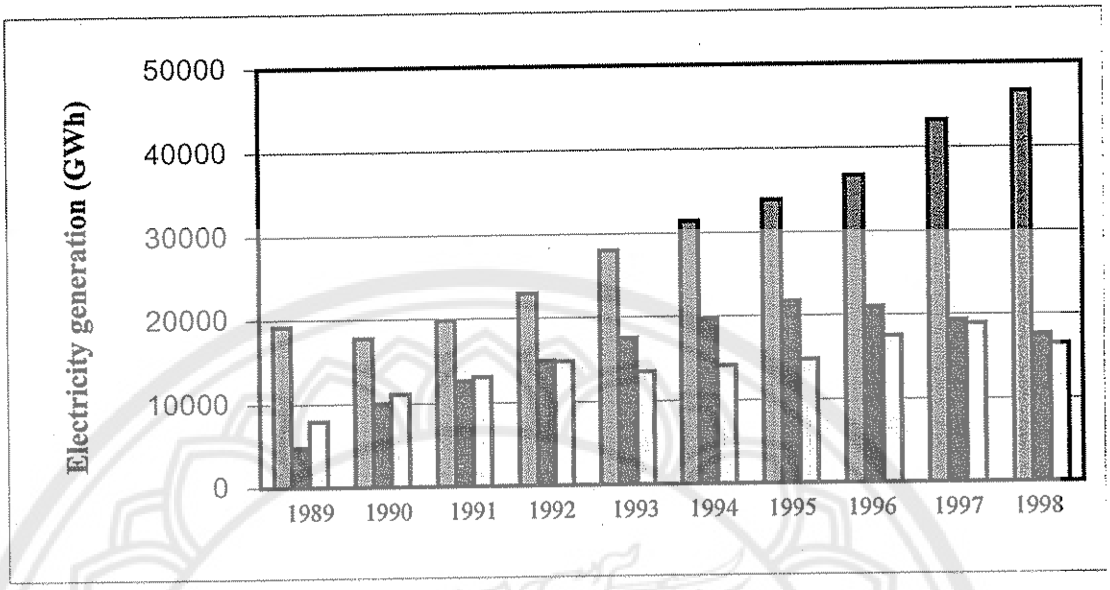
APPENDICES

APPENDICES

Table 11. CO_2 emission of electricity generation from fossil fuels

Year	Electricity generation from diesel (Mwh)	CO_2 emission (Tg)	Grid electricity					
			Natural gas (GWh)	CO_2 emission (Tg)	Fuel Oil (GWh)	CO_2 emission (Tg)	Lignite (GWh)	CO_2 emission (Tg)
1989	74	$7.33*10^{-5}$	19194.8	7.49	4738.8	2.80	7878.6	6.90
1990	75	$7.43*10^{-5}$	17767.6	6.93	10012.6	5.91	11052.8	9.68
1991	71	$7.03*10^{-5}$	19799.9	7.72	12636.4	7.46	13036.5	11.41
1992	68	$6.73*10^{-5}$	22943	8.95	14928.9	8.81	14815	12.97
1993	53	$5.25*10^{-5}$	27953.2	10.90	17494.5	10.32	13503.8	11.82
1994	54	$5.35*10^{-5}$	31409.7	12.25	19644.4	11.59	14130.9	12.37
1995	64	$6.34*10^{-5}$	33899.5	13.22	21714.6	12.81	14779.6	12.94
1996	71	$7.03*10^{-5}$	36748.9	14.33	20976.5	12.38	17507.2	15.33
1997	70	$6.93*10^{-5}$	43179.2	16.84	19303.6	11.39	18924.6	16.57
1998	60	$5.94*10^{-5}$	46571.4	18.16	17616.3	10.39	16476.7	14.43
Total	660	0.000653	299467.2	116.79	159066.6	93.85	142105.7	124.42



Source : EGAT, PEA and IPP

Figure 5. Electricity generation from different types of fuels

Natural gas   Oil   Coal

A: PV TECHNOLOGIES

PV comes in many flavors, though the bulk of the material in use today is silicon-based. In general, PV materials are categorized as either thick crystalline (sliced from boules or castings, or grown ribbons) or thin film (deposited in thin layers on a substrate) polycrystalline or amorphous. The following is information on the materials and technologies with application to photovoltaics.

Thick Crystalline Materials

Crystalline Silicon

Single-crystal silicon--Sliced from single-crystal boules of grown silicon, these wafers/cells are now cut as thin as 200 microns. Research cells have reached nearly 24-percent efficiency, with commercial modules of single-crystal cells exceeding 15-percent.

Multi-crystalline silicon--Sliced from blocks of cast silicon, these wafers/cells are both less expensive to manufacture and less efficient than single-crystal silicon cells. Research cells approach 18-percent efficiency, and commercial modules approach 14-percent efficiency.

Edge-defined film-fed growth ribbons--Nearly single-crystal silicon ribbons grown from a crucible of molten silicon, drawn by capillary action between the faces of a graphite die.

Dendritic web--A film of single-crystal silicon pulled from a crucible of molten silicon, like a soap bubble, between two crystal dendrites.

Gallium Arsenide (GaAs)

A III-V semiconductor material from which high-efficiency photovoltaic cells are made, often used in concentrator systems and space power systems. Research cell efficiencies greater than 25 percent under 1-sun conditions, and nearly 28 percent under concentrated sunlight. Multi-junction cells based on GaAs and related III-V alloys have exceeded 30-percent efficiency.

Thin-Film Materials

Amorphous Silicon (a-Si)

A non-crystalline form of silicon, first used in photovoltaic materials in 1974. In 1996, amorphous silicon constituted more than 15 percent of the worldwide PV production. Small experimental a-Si modules have exceeded 10-percent efficiency, with commercial modules in the 5-7-percent range. Used mostly in consumer products, a-Si technology holds great promise in building-integrated systems, replacing tinted glass with semi-transparent modules.

Cadmium Telluride (CdTe)

A thin-film polycrystalline material, deposited by electrodeposition, spraying, and high-rate evaporation, holds the promise of low-cost production. Small laboratory devices approach 16-percent efficiency, with commercial-sized modules (7200-cm^2) measured at 8.34-percent (NREL-measured total-area) efficiency and production modules at approximately 7 percent.

Copper Indium Diselenide ($CuInSe_2$, or CIS)

A thin-film polycrystalline material, which has reached a research efficiency of 17.7 percent, in 1996, with a prototype power module reaching 10.2 percent. The difficulty in taking this technology to a production level lies in the difficulty in avoiding the formation of defects during deposition that prevent the formation of uniform layers.

Concentrators

Concentrator systems use lenses or reflectors to focus sunlight onto the solar cells or modules. Lenses, with concentration ratios of 10x to 500x, typically Fresnel linear-focus or point-focus lenses, are most often made of an inexpensive plastic material engineered with refracting features that direct the sunlight onto a small or narrow area of cells. The cells are usually silicon. GaAs cells and other materials would have higher conversion efficiencies, and could operate at higher temperatures, but they are often substantially more expensive. Module efficiency can range upwards from 17%, and concentrator cells have been designed with conversion efficiencies in excess of 30%.

Reflectors can be used to augment power output, increasing the intensity of light on modules, or to extend the time that sufficient light falls on the modules. Concentrator system lenses are unable to focus scattered light, limiting their use to areas, like desert areas, with a substantial number of cloudless days on an annual basis.

B: THE NUMBER OF SINGLE CRYSTALLINE SILICON USED IN THAILAND

The utilization of PV in Thailand are independently conducted by government organizations, which depend on their functional responsibilities.

1. Provincial electricity Authority (PEA)

PV power plants with the installed capacity of 60, 60 and 30 kW. PEA with the assistantship from Government of Japan has established this project. The system consists of single crystalline silicon PV supplied by Sharp, lead acid battery storage and a DC-AC converter. Electricity is supplied to nearby villages through a 240 V 50 hz power line.

2. Electricity Generating Authority of Thailand (EGAT)

EGAT has included PV in its renewable programs since the late 1970s.

- 50 kW of PV modules which are produced from 10 different manufactures were used for tower and buoy warming lights, survey camp lighting, communication, microwave repeater and grid demonstration plants.

- 100 kW of PV were already installed for telecommunications

- 74 kW for grid connected system and 8 kW of signal light and the rest of miscellaneous systems,

- 18 kW for 8 houses in the PV roof top project (actually there are 10 houses in this project, 8 residences used a single crystal silicon cell with a capacity of 2.25 for each house and an amorphous silicon solar cells with a capacity of .88 kW each for 2 residences)

- 4 MW of PV power plants, with a capacity of 1 MW each, to demonstrate and assist stability of the transmission system which are located far away from the main power production sources.

3. Ministry of Education (ME)

- More than 65 kW PV modules were installed in remote primary schools for a program on 'Education by Radio'. All PV modules are single crystalline silicon, supplied by a local manufacturer.

4. Public Works Department (PWD)

- 973 kW of PV modules wee installed for battery charging systems in 912 villages.

- 652 kW for PV water pumping in 683 villages.

5. Department of Energy Development and Promotion (DEDP)

- 3-6 kW capacity is used to charge batteries at a battery charging center of rural electrification systems in the remote area. At present 300 villages have already been installed

- 4 kW PV battery charging system was set up for households in a village in Kanchanaburi Province and in the same project the larger system, 40 kW, was implemented at Koh Yao Yai. Moreover 60 kW was installed also in Koh Yao Yai which was support by NEDO.

6. 892 kW of PV systems for water pumping

Have already been installed in various regions of Thailand. PV system for Water pumping have been introduced for domestic use, and irrigation by various organization such as PWD, DEDP, Ministry of Public Health (MPH), King Mongkut's University of Technology Thonburi (KMUTT), the Royal Irrigation Department (RID).

C: THEORY OF GREENHOUSE EFFECT

How do we know that the natural greenhouse effect is real?

The natural greenhouse effect is real; it is a well understood effect, based on established scientific principle. The greenhouse effect works in practice, for several reasons.

Firstly, the mean temperature of the Earth's surface is already warmer by about 33°C (assuming the same reflectivity of the earth) that it would if the natural greenhouse gases were not present. Satellite observations of the radiation emitted from the Earth's surface and through the atmosphere demonstrate the effect of the greenhouse gases.

Secondly, we know the composition of the atmospheres of Venus, Earth and Mars are very different, and their surface temperatures are in general agreement with greenhouse theory.

Thirdly, measurements from ice cores going back 160,000 years shows that the Earth's temperature closely paralleled the amount of carbon dioxide and methane in the atmosphere. Although we do not know the details of cause and effect, calculations indicate that changes in these gases were part, but not all, of the reason for the large (5-7°C) global temperature swings between ice ages and interglacial periods.

How might human activities change global climate

Naturally occurring greenhouse gases keep the Earth warm enough to be inhabitable. By increasing their concentrations, and by adding new greenhouse gases like chlorofluorocarbons (CFCs), humankind is capable of raising the global-average annual-mean surface-air temperature (which, for simplicity, is referred to as the "global temperature"), although we are uncertain about the rate at which this will occur. Strictly, this is an enhanced greenhouse effect - above that occurring due to natural greenhouse gas concentrations; the word "enhance" is usually omitted, but it should not be forgotten. Other changes in climate are expected to result, for example changes in precipitation, and a global warming will cause sea levels to rise.

There are other human activities which have the potential to affect climate. A changes in albedo (reflectivity) of the land, brought about by desertification or deforestation affect the amount of solar energy absorbed at the Earth's surface. Human-made aerosols, from sulfur emitted largely in fossil fuel combustion, can modify clouds and this may act to lower temperatures. Lastly, changes in ozone in the stratosphere due to CFCs may also influence climate.

What is greenhouse effect?

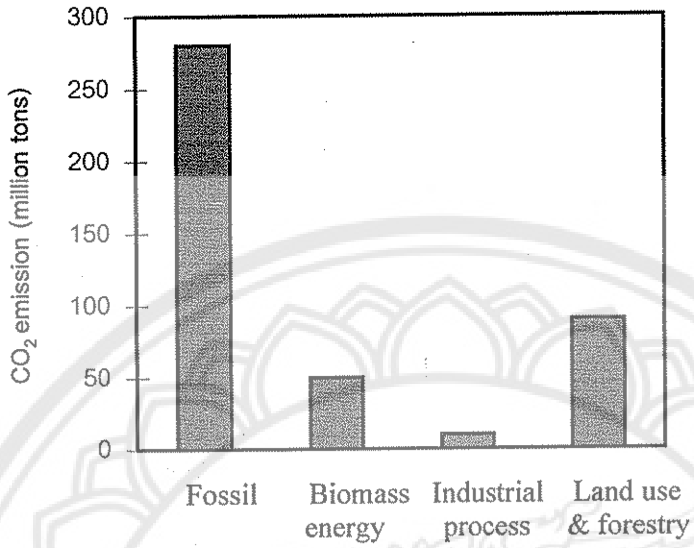
The greenhouse effect is not new, it is component of the Earth geophysical balance and has been occurring for the last two billion years. For thousand of millennia, natural background concentrations of greenhouse gas (principally water vapor and carbon dioxide: CO_2) trapped sufficient heat near the earth surface to raise the planet's average temperature by about 33 ^{O}C above what it would otherwise has been. The process increased the surface temperature from -18 to +15 ^{O}C . The warmer temperature allowed water to exist on the surface as a liquid, rather than ice and to become a medium for biological evolution of life.

But in the last century, this natural background process "greenhouse effect" has become the greenhouse problem. Human activities have steadily increased the concentrations of various heat - trapping gases, enhancing warming effect. The most dangerous of these trace gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the synthetic compounds called chlorofluorocarbons (particularly CFCs 11 and 12). Because of their atomic structure, these gases are transparent to incoming solar radiation. Most of the sunlight passes through them and is not absorbed. But the same gases absorb and re-emit light at longer wavelengths such as the thermal infrared radiation that is released naturally and continuously from the earth's surface. When these heat trapping gases release the energy they have absorbed, they re-emit it in all directions. The re-emitted radiation carries most of the heat upward, out of the atmosphere but some is re-emitted downward, warming air land and water below. The absorption of radiation by these heat trapping gases retains heat within the troposphere.

In effect, these gases act like a blanket , trapping heat close to the surface that would otherwise escape through the atmosphere to outer space and some observer of the heat trapping effect of the glass walls reminds in a horticultural greenhouse. An observed increase in global mean temperature of approximately 0.5 ^{O}C during the 20th century

Classification of Emission Sources

The International Panel for Climate Change (IPCC) has classified sources of greenhouse gas emission into Energy, industrial processes, solvent and other product use, agriculture, forestry and land use change and waste. The large quantity of CO_2 releases from energy, industrial processes and land use change and forestry. Methane creates mainly from agriculture and wastes while NMOVC comes from solvent releases activities. Figure 6 represent the quantitative list of CO_2 from the large sources of emission in Thailand.

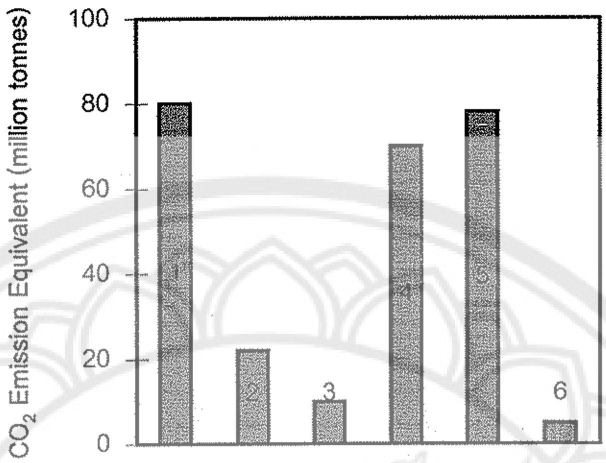


Source: Thailand's Presentation on Energy and Environment, 1998

Figure 6. Carbon dioxide emission inventory in 1995 from different sources.

It should be noted that although the quantity of CO_2 emission from the energy sector are much larger than CH_4 in terms of the carbon dioxide equivalent, the potential global warming of agriculture and forestry sector increase. Figure 7 compares the GHG emission in terms of CO_2 equivalent in Thailand in 1990.

However, an attempt to compare GHG emission from the agriculture and land use change and forestry which other sectors should be carried out cautiously. Because these two sectors contain large uncertainties in acquiring the Emission factors and Activity data. The estimation approach recommended by the IPCC for the energy source is within 97% inaccuracy while the agriculture and land use change and forestry are less than 50% inaccuracy.



Source: Thailand's Presentation on Energy and Environment, 1998

Figure 7. Carbon dioxide emission equivalent in Thailand in 1990

Note: 1 = Fossil Energy
2 = Biomass energy
3 = Industrial Process
4 = Agriculture
5 = Land Use & Forestry
6 = Waste

What are the greenhouse gases and why they are increasing?

Greenhouse gases include a wide variety of gases. They trap heat near the Earth's s surface, preventing its escape into space. Greenhouse gas include carbon dioxide, methane, nitrous oxide, chlorofluorocarbons (particularly CFCs 11 and 12) and water vapor. While greenhouse gases occur naturally in the atmosphere, human activities also produce greenhouse gas emission and are responsible for creating new one.

- **Water vapor** is produced from natural and human induced respiration, transpiration, evaporation and combustion of fossil fuels. The amount of water vapor released through evaporation increase as Earth's surface temperature rise.

- **Carbon dioxide (CO_2)** is the most common greenhouse gas released by human activities. The burning of fossil fuels, deforestation, and the burning of vegetation have contributed to an increase in the carbon dioxide in the atmosphere. In addition to such anthropogenic sources, the amount of CO_2 in the atmosphere is determined by the dynamic balance between production by living organism, removal by photosynthesis in plants and uptake into, or release from, store such as ocean. In the ocean, for example, uptake CO_2 is dominant in winter and release is dominant in summer.

Monthly concentration of CO_2 reveal not only an annual periodicity but also a long - term increase over the period 1958 - 1988, from approximately 315 ppm to 352 ppm. This amounts to an increase of 12%. As concentration in the middle of the 19th century were approximately 280 ppm, there has clearly been a recent acceleration in the rate on increase in atmospheric CO_2, which can be attributed to an anthropogenic source. Current predictions are that concentration will have exceeded 600 ppm by 2050 if no steps are taken to control emission from such sources. The role of the oceans as the major store of carbon is as yet not fully understood but they will certain exert a dominant control over future atmospheric CO_2 level. It has been estimated that of 100 molecules of CO_2 injected into the atmosphere:

6 molecules will dissolve in the ocean in	1	year
29 molecules will dissolve in the ocean in	10	years
59 molecules will dissolve in the ocean in	60	years
84 molecules will dissolve in the ocean in	360	years
100 molecules will dissolve in the ocean in	>1000	years

The first 6 molecules dissolve in the surface waters. The next 23 result from transport between the surface waters and the thermocline. The next 55 molecules result from transport to the deep ocean. The last 16 molecules (16% of the injected CO_2) represent that essential remains in the atmosphere.

- **Methane (CH_4)** is derived from the bacterial breakdown of organic matter in swamp, paddy fields and waste tips and in cattle, together with direct leakage during fossil fuels extraction. It is currently increase at the rate of approximately 1% per year.

- **Nitrous Oxide (N_2O)** is a byproduct of fertilizer manufacture and use, and of fossil fuel and biomass burning. It is also emitted from vehicle exhausts and is, therefore, a particular problem in large cities such as Los Angles and Mexico City, where strong solar radiation in its photochemical conversion to a noxious urban haze. Atmospheric N_2O is currently increasing at approximately 0.4% per year.

- **CFCs** are exclusively an industrial product, being used as coolants in fridge and air-conditioning systems, propellants in aerosol cans, and in the production of plastic foams. International agreements such as the Montreal Protocol of 1987 may slow down the annual rate of increase in atmospheric CFC, which is currently 6% per year.

For a thousand of years prior to the industrial revolution, abundances of the greenhouse of the greenhouse gases were relatively constant. However, as the world's population increased, as the world became more industrialized and as agriculture developed, the abundances of greenhouse gases increased markedly.

Since the industrial revolution the combustion of fossil fuels and deforestation have led to an increased of 26% in carbon dioxide concentration in the atmosphere. We know the magnitude of the present day fossil fuel source, but the input from deforestation cannot be estimated accurately. In addition, although about half of the emitted carbon dioxide stays in the atmosphere, we do not know well how much of the remainder is absorbed by the oceans and how much by terrestrial biota. Emission of chlorofluorocarbons, used as aerosol propellants, solvents, refrigerants and foam blowing agents are also well known; they were not present in the atmosphere before their invention in the 1930s.

The sources of methane and nitrous oxide are less well known. Methane concentrations have more than doubled because of rice production, cattle rearing, biomass burning, coal mining and ventilation of natural gas also fossil fuel combustion may have also contributed through chemical reactions in the atmosphere which reduce the rate of removal of methane. Nitrous oxide has increased by about 8% since pre-industrial times, presumably due to human activities; we are unable to specify the sources, but it is likely that agriculture plays a part.

How can we evaluate the effect of different greenhouse gases?

To evaluate possible policy options, it is useful to know the relative radiative effect (and, hence, potential climate effect) of equal emission of each of the greenhouse gases. The concept of relative Global Warming Potentials (GWP) has been developed to take into account the differing times that gases remain in the atmosphere.

This index defines the time-integrated warming effect due to an instantaneous release of unit mass (1 kg) of a given greenhouse gas in today's atmosphere, relative to that of carbon dioxide. The relatives importance will change in the future as atmospheric composition changes because, although radiative forcing increases in direct proportion to the concentration of CFCs, changes in the other greenhouse gases (particularly carbon dioxide) have an effect on forcing which is much less than proportional.

The GWPs in Table 12 are shown for three time horizons, reflecting the need to consider the cumulative effects on climate over various time scales. The longer time horizon is appropriate for the cumulative effect; the shorter time scale will indicate the response to emission changes in the short term. There are a number of practical difficulties in devising and calculating the values of the GWPs, and the values given here should be considered as preliminary. In addition to these direct effects, there are indirect effects of human-made emission arising from chemical reactions between the various constituents. The indirect on stratosphere water vapor, carbon dioxide and tropospheric ozone have been included in these estimates.

Table 12 indicates, for example, that the effectiveness of methane in influencing climate will be greater in the first few decades after release, whereas emission of the longer lived nitrous oxide will affect climate for a much longer time.

The lifetimes of the proposed CFC replacements range from 1 to 40 years; the longer lived replacements are still potentially effective as agents of climate change. One example of this, HCFC-22 (with a 15 years lifetime), has a similar effect (when released in the same amount) as CFC-11.

Table 12 shows carbon dioxide to the least effective greenhouse gas per kilogram emitted, but its contribution to global warming , which depends on the product of the GWP and the amount emitted, is largest.

Table 12. Global Warming Potentials. The warming effect of an emission of 1 kg of each gas relative to that of CO_2. These figures are best estimates calculated on the basis of the present day atmospheric composition.

	Time Horizon 20 yr.	100 yr.	500 yr.
Carbon dioxide	1	1	1
Methane (including indirect)	63	21	9
Nitrous oxide	270	290	190
CFC-11	4500	3500	15000
CFC-12	7100	7300	4500
HCFC-22	4100	1500	510

How quickly will global climate change?

1. If emission follow a Business-as-Usual pattern

a. Under the IPCC Business-as-Usual (Scenario A) emission of greenhouse gases, the average rate of increase of global mean temperature during the next century is estimated to be about 0.3 ^{O}C per decade (with an uncertainty range of 0.2 ^{O}C to 0.5 ^{O}C). This will result likely increase in global mean temperature of about 1 ^{O}C above the present value (about 2 ^{O}C above that in the pre-industrial period) by 2025 and 3 ^{O}C above today's (about 4 ^{O}C above pre-industrial) before the end of the next century.

b. If emission are subject to controls

Under the other IPCC emission scenario which assume progressively increasing levels of controls, average rates of increase in global mean temperature over the next century are estimated to be about 0.2 ^{O}C per decade (Scenario B), just above 0.1 ^{O}C per decade (Scenario C) and about 0.1 ^{O}C per decade (Scenario D).

The indicated range of uncertainty in global temperature rise given above reflects a subjective assessment of uncertainties in the calculation of climate response, but does not include those due to the transformations to concentrations, nor the effects of greenhouse gas feedback.

The effect of greenhouse effect to the Earth

1. **The effect of the changing the sea level**

Change of global temperature affect components of global hydrological cycle indifferent ways and different response time. Higher temperature increase the amount of water vapor in the atmosphere. Precipitation patterns alter and affect runoff from rivers and glaciers into the ocean waters expand. Catastrophic collapse of ice sheets has been suggested as another consequence of rising temperatures that might cause a rise of sea level.

Simple models were used to calculate the rise in sea level to the year 2100. The calculations necessarily ignore any long-term changes, unrelated to greenhouse forcing, that may occurring but cannot be detected from the present data on land ice and the ocean. An average rate of global mean sea level rise of about 6 cm per decade over the next century (with an uncertainty range of 3-10 cm per decade). The predicted rise is about 20 cm in global mean sea level by 2030, and 65 cm by the end of the next century. There will be significant regional variations.

The best estimate in each case is made up mainly of positive contributions from thermal expansion of the oceans and melting of glaciers. Although, over the next 100 years, the effect of the Antarctic and Greenland ice sheets is expected to be small, they make a major contribution to the uncertainty in predictions.

Even if greenhouse forcing increase no further, there would still be a commitment to a continuing sea level rise for many decades and even centuries, due to delays in climate, ocean and ice mass responses. An illustration, if the increases in greenhouse gas concentrations were to suddenly stop in 2030, sea level would go on rising from 2030 to 2100, by as much again as from 1990-2030.

2. **The effects on ecosystem**

Ecosystem processes such as photosynthesis and respiration are dependent on climatic factors and carbon dioxide concentration in the short term. In the longer term, climate and carbon dioxide are among the factors which control ecosystem structure, i.e., species composition, either directly by increasing mortality in poorly adapted species, or indirectly by mediating the competition between species. Ecosystems will respond to local changes in temperature (including its rate of change), precipitation, soil moisture and extreme events. Current models are unable to make reliable estimates of changes in these parameters on the required local scales.

Photosynthesis captures atmospheric carbon dioxide, water and solar energy and stores them in organic compounds when are then used for subsequent plant growth, the growth of animals or the growth of microbes in the soil. All of these organisms release carbon dioxide via respiration into the atmosphere. Most land plants have a system of photosynthesis which will respond positively to increased atmospheric carbon dioxide (the carbon dioxide fertilization effect) but the response plants have a system of photosynthesis which will respond positively to increased atmospheric carbon dioxide (the carbon dioxide fertilization effect) but the respond varies with species. The effect may decrease with time when restricted by other ecological limitations, for example, nutrient availability. It should be emphasized that the carbon content of the terrestrial biosphere will increase only if the forest ecosystems in a state of maturity will b able to store more carbon in a warmer climate and at higher concentrations of carbon dioxide. We do not yet know if this is the case.

The response to increased carbon dioxide results in the greater efficiencies of water, light and nitrogen use. These increased efficiencies may be particularly important during drought and in arid/semi-arid and infertile areas. Because species respond differently to climate change, some will increase in abundance and/or while other will decrease. Ecosystems will therefore change in structure and composition. Some species may be displaced to higher latitudes and latitudes, and may be more prone to local, and possibly even global, extinction; other species may thrive.

As stated above, ecosystem structure and species distribution are particularly sensitive to the rate of change of climate. We can deduce something about how quickly global temperature has changed in the past from palaeoclimatological records. As an example, at the end of the last glaciation, within about a century, temperature increased by up to 5^{O}C in the North Atlantic region, mainly in western Europe. Although during the increase from the glacial to the current inter glacial temperature simple tundra ecosystems responded positively, a similar rapid temperature increase applied to more developed ecosystems could result in their instability.

3. **The effect on Crops and agriculture**

3.1 Effect of CO_2 increases on plant growth

The impacts of elevated concentrations of CO_2 on crop growth and yield have been studied for nearly 100 years (Mintzer. 1993 : 75). The effects of other gases; methane, dinitrogen oxides and chlorofluorocarbons have yet to receive similar attention. Early experiments that increased the CO_2 concentration in greenhouses resulted in yield enhancement in lettuce, tomatoes, cucumbers and several ornamental plant. Bert Bolin. et al. (1986) assembled 770 observations on the impact of higher levels of atmospheric CO_2 in crop yield, and found that the yield increase overall was of the order of 32% (if all other growth-related factors were held constant).

Why does this take place? The most direct effect of high levels f CO_2 that has been verified in plants is an increase in leaf and canopy photosynthetic rates. It has been observed that an increase in photosynthesis may continue at concentrations up to four times the pre-industrial level of CO_2, or 1000 ppm (Mintzer. 1993 : 75). Increased metabolic activity in plants may lead to conversion of up to 51% of the CO_2 that was transformed into carbohydrates being oxidized through photorespiration, and released again as CO_2. In the long term, photorespiration rates are likely to decrease with a rise in atmospheric CO_2 levels.

An increase in biomass production in variably occurs with CO_2 enrichment. This may not always come from an increase in net photosynthesis. Increasing CO_2 concentration leads to a partial closure of leaf stomates. This reduces leaf transpiration rates, and promote water use efficiency is an important outcome of higher levels of CO_2. Some studies have shown that the yields of wheat varieties subjected to water stress were as high or even higher at high CO_2 levels, as compared to wheat grown with adequate irrigation but at normal CO_2 levels.

3.2 The effect of geographical limits to agriculture.

- Changes in thermal limits to agriculture

Increase in temperature can be expected to lengthen the growing season in areas where agricultural potential is currently limited by insufficient warmth; resulting in a poleward shift of thermal limit of agriculture. The consequent extension of potential will be most pronounced in the north hemisphere, because of the greater extent here of temperate agriculture at higher latitudes.

While warming may extend the margin of potential cropping and grazing in mid-latitude regions, it may reduce yield potential in the core areas of current production. This is because higher temperatures encourage more rapid maturation of plants and shorten the period of grain filling. An important additional effect, especially in mid-latitudes, is likely to be the reduction of winter chilling (vernalization). Many temperate crops (such as barley and oats) require a period of low temperatures in winter, to either initiate or accelerate the flowering process. Reduce vernalization and, ultimately, reduced yields. It has been estimated that a 1°C warming would reduce effective winter chilling by between 10 and 30%, thus contributing to a poleward shift of temperate crops.

Increase in temperature are also likely to affect the crop calendar in low latitude regions, particularly where more than one crop is harvested each year. For example, in Sri Lanka and Thailand a 1°C warming would probably require a substantial re-arrangement of the current crop calendar, which is finely tuned to present climatic conditions.

- Shifts of moisture limits to agriculture

There is much less agreement between GCM-based projections concerning greenhouse gas-induced changes in precipitation, than there is about temperature - not only concerning changes of magnitude, but also of spatial pattern and distribution through the year. For this reason it is difficult to identify potential shifts in the moisture limits of agriculture. This is particularly so because relatively small changes in the seasonal distribution of rainfall can have disproportionately large effects on soil moisture, and thus on the viability of agriculture in tropical areas. This influence takes place largely through changes in growing period when moisture is sufficient, and thus through the timing of critical episodes such as planting.

However, recent surveys for the IPCC have made a preliminary identification of those regions where there is some agreement among the GCM experiments, concerning the regional implications for soil water availability if a doubled level of atmospheric CO_2 come to pass. It should be emphasized that coincidence of results for these regions is not statistically significant.

- Regions affected by drought, heat stress and other extremes

Probably among the most important impacts of global warming for agriculture, but about which least is known, are the possible changes in climatic extremes; such as magnitude and frequency of drought, storms, heat waves and severe frosts. Some modeling evidence suggests that hurricane intensities will increase with climatic warming. This has important implications for agriculture in low latitudes, particularly in coastal regions.

There is a distinct possibility that as a result of high rates of evaporation, some regions in the tropics and high rates of evapotranspiration, some regions in the tropics and sub-tropics could be characterized by a higher frequency of drought, or a similar frequency of more intense drought, than at present. Current uncertainties about how regional patterns of rainfall will alter mean that no useful prediction of this can at present be made. However, it is clear in some regions that relatively small decreases in water availability can readily produce drought conditions. In India, for example, lower than-average rainfall in 1987 reduced food grains production from 152 to 134 million tons (Mt), lowering food buffer stocks from 23 to 9 Mt. Changes in risk and intensity if drought, especially in currently drought-prone regions, represent potentially the most serious impact of climate change on agriculture both at the global and the regional level.

- Effects on the distribution of agriculture pets and diseases

Studies suggest that temperature increases may extend the geographic range of some insect pets currently limited by temperature. As with crops, such effects would probably be greatest at higher latitudes. The number of generations per year produced by multivoltine (i.e. multigenerational) pests would increase, with earlier establishment of pest populations in the growing season and increased abundance during more susceptible stages of growth.

An important unknown, however, is the effect that changes in precipitation amount and air humidity may have on the insects pets themselves and on their predators, parasites and diseases. Climate change may significantly influence interspecies interactions between pets and their predators and parasites.

Electricity and greenhouse

There is no form of energy conversion, such as turning primary energy into electricity, without some environmental implications. In recent years attention has been focused on the climate change effects of burning fossil fuels, especially coal, due to carbon dioxide which this releases to the atmosphere.

Carbon dioxide contributes about half of the human-induced increase in the greenhouse effect. Electricity generating causes emission of CO_2, which is one of the most important greenhouse gases. Fuels used in electricity generating are fuel oil, diesel oil, natural gas, lignite and imported coal. These fuels consist mainly of a mixture of hydrocarbon compounds differing in their group composition, which determine the chemical structure of the fuel, and elementary composition. In the electricity generation, fuels have to combust and if we suppose that it is complete combustion, the reaction between the elements in the fuel with oxygen will happen.

In complete combustion it is assumed that the reactions between the carbon and hydrogen of the fuel and oxygen of the air produce, respectively, carbon dioxide and water vapor, the equation below described the combustion of fuels.

$C + O_2 = CO_2$ and $2H_2 + O_2 = 2H_2O$

So CO_2 is the major gases that produced from combustion of fossil fuels to produce electricity and also the major gases of greenhouse effect.

The international policy to protect the climate

- In 1972, the Stockholm Conference was a starting point or tracing the development of international policy, which resulted in the formation of the UN Environment Program (UNEP).

- In 1979, the Geneva Conference Climatic change was sufficient concern for the first world climate conference.

- In 1987, another landmark was the publication of ' Our common future ' by the Brundt land Commission, which called for the protection of the atmosphere and the reduction of greenhouse gas emission.

- In 1985 Vienna Convention and the 1987 Montreal Protocol on substances that deplete the ozone layer are major examples of international agreements to protect the atmosphere.

- In 1988, Climate change was placed firmly on the world's agenda by the Toronto conference. The conference statement called for the reduction of CO_2 emission by 20% of the 1988 levels by 2005. In the same year the Intergovernmental Panel on Climate Change (IPCC) was established by UNEP and the World

Meteorological Organization. The IPCC is an intergovernmental scientific and technical body consisting of a small secretariat, a bureau and global network of about 2,500 scientists and experts. The IPCC publishes authoritative assessments of climate change. The latest assessment was published in 1996.

The Intergovernmental Panel on Climate Change (IPCC) developed long-term emission scenarios in 1990 and 1992. These scenarios have been widely been used in the analysis of possible climate change, its impacts, and options to mitigate climate change. In 1995, the IPCC 1992 scenarios were evaluated. The evaluation recommended that significant change (since 1992) in the understanding of driving forces of emission and methodologies should be addressed. These changes in understanding relate to, e.g., the carbon intensity of energy supplies, the income gap between developed and developing countries, and to sulfur emission. This led to a decision by IPCC Plenary in 1996 to develop a new set of scenarios.

In case of Thailand

At present, the power sector produces an estimated 29 million tons of CO_2 each year (equivalent to about 7.9 million tons of carbon), about 33% of Thailand's total emission from fuel consumption. During the next decade, the power sector will surpass transportation as the principal source of CO_2 emission in Thailand, accounting for 43 percent of total emission in 2006. This significant change results from two principal factors.

- A substantial increase in the amount of installed capacity

- Dramatically increased reliance on lignite and coal as sources of fuel, which release more CO_2 per unit of energy than other fuels.

In 1994, Thailand ratified the Climate Change Convention. It has also signed the Kyoto Protocol in 1999 but has yet to ratify it. Thailand has activities to support the Protocol such as;

- In 1997, the Kyoto Protocol established clear targets for Article (developed)countries during 2008-2012 relative to 1990 levels.

- Government has implemented a program to reduce CO_2 discharge from energy sector through DSM (Demand Side Management) program.

- Several studies were also undertaken to establish the 1990 baseline data and develop a country strategy for GHG.

- An energy conservation fund aimed especially at big buildings, has been established.

Table 13. Greenhouse Gases

Compound	Mixing Ratio (ppb) 1992	Lifetime (yr.)	Greenhouse Efficiency[a]	Importance for Climate
O_3	10-200	c		absorbs UV and IR radiation[d]
CO_2	356000	200[b]	1	absorbs IR; affects stratospheric O_3
CH_4	1714	11	21	absorbs IR; affects stratospheric O_3 &OH; affects stratospheric O_3 & H_2O
N_2O	311	120	206	absorbs IR; affects stratospheric O_3
$CFCl_3$ (CFC-11)	0.268	50±5	12400	absorbs IR; affects stratospheric O_3
CF_2Cl_2(CFC-12)	0.503	102	15800	absorbs IR; affects stratospheric O_3
CF_2HCl(HCFC-22)	0.105	13.3	10660	absorbs IR; affects stratospheric O_3
CH_3CCl_3	0.160	5.4±0.6	2730	absorbs IR; affects stratospheric O_3
CF_3Br(H-1301)	0.002	65	16000	absorbs IR; affects stratospheric O_3
$C_2F_3Cl_3$(CFC-113)	0.082	85		absorbs IR; affects stratospheric O_3
CF_2ClCF_2Cl(CFC-114)	0.02	300		absorbs IR; affects stratospheric O_3
C_2F_5Cl(CFC-115)	<0.01	1700		absorbs IR; affects stratospheric O_3
CCl_4	0.132	42		absorbs IR; affects stratospheric O_3
CH_3CFCl_2(HCFC-141b)	-	9.4		absorbs IR; affects stratospheric O_3
CH_3CF_2Cl(HCFC-142b)	0.0035	19.5		absorbs IR; affects stratospheric O_3
CF_3CH_2F(HFC-134a)	-	14		absorbs IR; affects stratospheric O_3
CH_2F_2(HFC-32)	-	6		absorbs IR; affects stratospheric O_3

[a] Per molecule relative to CO_2 (IPCC,1995)

[b] CO_2 lifetime difficult to estimate. This is for a combined lifetime in atmosphere, biosphere and upper ocean.

c O_3 lifetime is on the order of few hour. Life time of O_x (O_3+O) is strongly dependent on location, varying from about 1 h in the upper stratosphere to months in the lower stratosphere, to hours to days in the troposphere.

[d] An important absorber of both solar and infrared radiation. An increase in troposphere O_3 or decrease in stratospheric O_3 would increase surface temperatures. Although only 10% of the total O_3 resides in the troposphere, on a per molecule basis, tropospheric O_3 (particularly in the upper troposphere) has a much stronger effect on surface temperature than stratospheric O_3

Table 14. Thailand's national Greenhouse Gas Inventory in 1990 unit: Gg (10^3 Gg = 1 million ton)

Greenhouse gas source and sink categories	CO_2 emission	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOC
Total National emission and Removals	188,956.32	-24,960.58	2,746.37	11.31	505.39	2,340.27	671.97
1. All Energy (Fuel combustion + Fugitive)	76,731.25	0.00	117.58	1.48	480.73	1,630.73	671.79
A. Fuel Consumption	76,731.25	0.00	9.82	1.48	480.73	1,630.73	651.01
Energy & Transformation Industries	28,243.42		0.61	0.08	110.23	7.43	-
Industry (TSIC), Mining & Construction	12,844.79		0.52	0.07	47.54	19.95	0.78
Transport	27,634.08		7.86	1.11	246.17	1546.50	634.63
Small Combustion	8,008.96		0.83	0.22	76.79	56.85	15.60
B. Fugitive emission from Fuels	0.00	0.00	107.75	0.00	0.00	0.00	20.78
Solid Fuels			10.40				
Oil & National Gas			97.35				20.78
2. Industrial Processes	9,806.72		0.32				0.17
Solvent & Other Product Use							
3. Agriculture	0.00	0.00	2,454.22	9.64	17.66	463.05	0.00
A. Enteric Fermentation			530.13				
B. Manure Management			115.98				
C. Rice Cultivation			1786.06				
D. Agricultural Soils				9.15			
E. Prescribed Burning of Savannas							
F. Field Burning of Agricultural Residues			22.05	0.49	17.66	463.05	
G. Other							

Table 14. Continue

Greenhouse gas source and sink categories	CO_2 emission	CO_2 removals	CH_4	N_2O	NO_x	CO	NMVOC
4. Land Use Change & Forestry	102,418.35	-24,960.58	28.17	0.19	7.00	246.49	0.00
A. Changes in Forest and Other Woody Biomass Stocks	20,709.92	-812.50					
B. Forest and Grassland conversion	81,708.42		28.17	0.19	7.00	246.49	
c. Abandonment of Managed Lands		-24,148.08					
D. Other							
5. Waste	0.00	0.00	146.09	0.00	0.00	0.00	0.00
A. Solid Waste Disposal on Land			121.41				
B. Wastewater Treatment			24.68				

Note: 1. CO_2 emission from traditional biomass burning are not included in subtotals and the national total.
2. CO_2 equivalents are based on GWPs of 21 for CH_4 and 310 for N_2O. NO_x and CO are not include since GWPs have not been developed for these gases.
3. Bunker fuel emission are not included in the national total.

Table 15. Global sources, concentrations, and atmospheric reactions of trace gases

Pollutant	Major sources	Natural sources	Estimated emission (tons)		Atmospheric background concentration	Calculated atmospheric residence time	Removal reactions and sinks
			man-made	natural			
SO_2	Combustion of Coal and oil	Volcanoes	146×10^6	None	0.2 ppb	4 days	Oxidation to Sulfate or after absorption by solid &Liquid aerosols
H_2S	Chemical Processes, sewage treatment	Volcanoes, biological action in swamp	3×10^6	100×10^6	0.2 ppb	2 days	Oxidation to SO_2
CO	Auto exhaust, other combustion	Forest fires, terpene reactions, ocean	274×10^6	75×10^6	0.1 ppm	3 days	Soil fungi, large sink necessary
NO/NO_2	Combustion	Bacterial action in soil	53×10^6	NO: 430×10^6 NO_2: 685×10^6	NO: 0.2-2 ppb NO_2: 0.5-4 ppb	5 days	Oxidation to nitrate after aerosol absorption, photochemical reactions
NH_3	Waste treatment	Biological decay	4×10^6	1160×10^6	6-20 ppb	7 days	Formation of ammonium sulfate, oxidation to nitrate
CO_2	Combustion, release from ocean, decay	Biological	1.4×10^6	1012	320 ppm	2-4 years	Absorption in oceans and biologically
HCs	Combustion, chemical processes	Biological	88×10^6	480×10^6	CH_4: 1.5 ppm	CH_4 : 16 yr.	Photochemical reactions, large sink necessary for methane

Source: E. Robinson and R.C. Robbins. Sources, Abundance, and Fate of Gaseous Atmospheric Pollutants. Standford Research Institute, Report SRI Project PR-6755
February 1968. Supplemental Report, June 1969

Table 16. Greenhouse Gases Emission From Fuel Combustion by fuel type and sector in 1990 (Gg)

Fuel type	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs
Fossil	76,731.2	9.8	1.5	480.7	1,630.5	651.0
Solid	13,570.4	0.1	0.1	58.8	4.6	0.0
Liquid	52,703.8	9.2	1.4	379.9	1,621.4	651.0
Gas	10,457.0	0.5	NA	NA	42.0	NA
Biomass	36,529.1	450.6	0.9	30.9	2,005.4	NA
Total	113,260.4	460.5	2.3	511.7	3,636.0	651.0
Sector						
Fossil	76,731.2	9.8	1.5	480.7	1,630.7	651.0
Power	28,243.4	0.6	0.1	110.2	7.4	NA
Agriculture	5,552.8	0.8	0.1	74.9	56.5	15.6
Residential & Commercial	2,456.2	0.1	0.1	1.9	0.4	0.0
Industrial, Mining & Construction	12,844.8	0.5	0.1	47.5	20.0	0.8
Transportation	27,634.1	7.9	1.1	246.2	1,546.5	634.6
Biomass	36,529.2	6.7	0.4	46.8	3,411.8	0.0
Residential & Commercial	17,727.4	6.7	NA	35.4	3,209.4	NA
Industrial	18,801.8	0.1	NA	11.4	202.4	NA
Total	113,260.4	16.5	1.9	527.6	5,042.6	651.0

Source: Thailand Environment Institute, 1997.

Table 17. CO_2 Emission by Sector in BAU Case

Sector	1994		1995		2000		2010		2020	
	million tone	%	million tone	%	million tone	%	million tone	%	million tone	%
Industrial	43.3	23.9	49.4	24.0	73.5	26.6	138.6	28.6	233.0	23.0
Transport	49.8	27.5	58.2	28.3	70.1	25.4	93.1	19.2	112.5	14.5
Commercial	0.4	0.2	0.5	0.2	0.3	0.1	0.6	0.1	0.9	0.1
Residential	33.0	18.2	38.6	18.7	44.4	16.1	47.1	9.7	46.4	6.0
Agriculture	4.0	2.2	4.9	2.4	6.4	2.3	7.3	1.5	11.9	1.5
Power Generation	50.4	27.9	54.16	26.32	81.6	29.5	198.3	40.9	372.5	47.9
Total	181.0	100.0	205.8	100.0	276.3	100.0	485.0	100.0	777.2	100.0

Source: Result of optimization, 1997