SINGAPORE'S INITIAL NATIONAL COMMUNICATION – Under the United Nations Framework Convention on Climate Change

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PREFACE

The United Nations Framework Convention on Climate Change (UNFCCC) provides a platform for countries to collectively avert the threat of global warming based on the principle of common but differentiated responsibilities.

The Republic of Singapore was among the 154 countries that signed the UNFCCC at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro, Brazil.

Singapore is a small island city-state of 648 square kilometres and 4 million people. We are not endowed with natural resources and are totally dependent on imported fossil fuels for our energy needs. Our economic development has been reliant upon the manufacturing and service sectors. There is little potential for us to develop alternative sources of energy that are non-fossil fuels based. Because of our economic structure and dependence on fossil fuels, our carbon dioxide emissions will inevitably grow as our economy develops.

Despite being in this difficult position with respect to the UNFCCC, Singapore ratified it on 29 May 1997 to demonstrate our commitment to join the international community in mitigating climate change. The ratification entered into force on 27 August 1997, and we are obliged to submit the initial communication by 26 August 2000.

Although Singapore, as a developing country, is not obligated under the UNFCCC to set emission control targets, we have made efforts to contain our greenhouse gas emissions. The efforts are described in this communication. Singapore will continue to promote optimal utilisation of energy in an effort to minimise greenhouse gas emissions.

Lee Yock Suan
Minister for the Environment
Republic of Singapore

Executive Summary

Country Circumstances

Singapore is a small island located near the Equator between latitudes 1° 09′N and 1° 29′N and between longitudes 103° 36′E and 104° 25′E, with a total land area of 647.5 square kilometres. Much of the island is less than 15 metres above sea level. The coast is flat and a considerable stretch of the 150-kilometre coastline has been modified by reclamation work, building of embankments and redevelopment.

Singapore is an equatorial country with relatively uniform temperature, abundant rainfall and high humidity. The average daily temperature is 26.8°C and annual rainfall is 2,344 millimetres. The average daily relative humidity is 84.3 percent.

Water and Food

Singapore is not self sufficient in both water and food supply. More than 50 percent of its potable water is imported from Malaysia. About 90 percent of food consumed in Singapore is imported. There is a small agricultural sector that focuses mainly on produce such as eggs, fish and vegetables for local consumption, and on orchids and ornamental fish for export.

Population

As at June 1998, the resident population, comprising Singapore citizens and permanent residents, is estimated at 3.2 million, made up of 77 percent Chinese, 14 percent Malay, 7.6 percent Indian and a small percentage of other races. The total population, including foreigners working in Singapore, is estimated at 3.9 million.

Singapore is a small island located near the Equator.

Economy and Development

Over the last three to four decades, Singapore has transformed its economy from one dependent largely on entrepot trade to a multi-faceted one. Singapore's Gross Domestic Product (GDP) in 1998 was S$141 billion (US$84 billion, based on the average exchange rate in 1998). The economic structure in 1998 was as follows:

Sector	% of GDP
Manufacturing	23.0
Construction	9.3
Wholesale & retail	14.0
Hotels & restaurants	2.6
Transport & communications	10.4
Financial services	13.1
Business services	14.0
Others	13.6

Environmental Management

While building up the economy over the years, Singapore spared no effort in looking after the environment. Singapore's environmental policies are based on the principle of balancing development and the environment, and on the goal of a clean and green environment. Ambient air quality is within World Health Organisation (WHO) and United States Environmental Protection Agency (USEPA) standards. Inland waters support aquatic life and the coastal waters meet recreational water standards. Environmental public health standard is high and the infectious disease situation is well under control.

Special Considerations under Article 4.8 of UNFCCC

Article 4.8[1] of the UNFCCC provides for special consideration for developing countries in certain circumstances. Three sub-clauses in the article are of specific relevance to Singapore, namely:

- Small island countries;
- Countries with low-lying coastal areas; and
- Countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products.

Being a small island country with low-lying coastal areas, Singapore is vulnerable to changes in sea level. Singapore also lacks natural

[1] Article 4.8 of the UNFCCC states that Parties shall give full consideration to actions to meet the specific needs and concerns of developing country Parties arising from the adverse effects of climate change and/or the impact of the implementation of responsive measures.

resources. To date, there are no renewable energy sources that Singapore can harness in an economically viable way to reduce its reliance on fossil fuels. In the absence of alternative energy sources, Singapore has to rely on fossil fuels for primary activities such as power generation and transportation.

Greenhouse Gas Emissions

Singapore's main greenhouse gas (GHG) emissions are carbon dioxide (CO_2) from the use of energy to meet development and human needs. With further development, population growth and an improving standard of living, energy consumption and the consequent greenhouse gas emissions are expected to increase.

Despite the lack of land, Singapore has put in a concerted effort to conserve trees, and in the process, to create carbon sinks. Nineteen nature areas (amounting to about 5 percent of total land area) have been identified for conservation, including some 2,100 hectares of forests. In addition, some 940,000 trees and more than 8 million shrubs have been planted in public spaces islandwide. Singapore has done remarkably well in "greening" the cityscape with trees, vegetation and parks despite the very limited land area. The principal means available to Singapore to mitigate GHG emissions are to increasingly replace the use of fuel oil with natural gas and to use energy as efficiently as possible.

National Greenhouse Gas Inventory for 1994

Singapore's emission estimates for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) were computed using the Revised 1996 IPCC[2] Guidelines for National Greenhouse Gas Inventories. The GHG emissions from agriculture, and land use change and forestry sectors are negligible.

CO_2 emissions for 1994 totalled 26,800 gigagrams CO_2-equivalent. The energy sector accounted for 99 percent of the total emissions. The remaining 1 percent is from the waste sector. A breakdown of our total greenhouse gas emissions by sources is shown in Table 1.

Vulnerability and Adaptation

Singapore is vulnerable to the following concerns arising from climate change:

- Land Loss and Coastal Erosion
  This issue can be overcome by engineering solutions and maintenance of the coastline at the appropriate time.

[2] Intergovernment Panel on Climate Change, a scientific and technical international body.

- Water Resources
  Singapore's impounded reservoirs are designed to minimise the risk of seawater infiltration from a rise in sea level. Although Singapore is not self sufficient in fresh water, measures are being taken to ensure that there will be enough potable water to meet the needs of the country. These measures include desalination, water reuse and water conservation.
- Flooding
  There is a system in place to monitor the storm-water drainage and flooding situation closely so that timely action can be taken to ensure that flooding will be minimised. Flood prevention and protection programmes are planned and implemented on an on-going basis.
- Public Health Impact from Resurgence of Diseases
  Singapore has a vigorous system to control and manage communicable diseases. We will continue to improve and adapt the system to take care of any adverse development on diseases caused by climate change.

Greenhouse Gas Source and Sink Categories	CO_2	CH_4	N_2O
Total (Net) National Emission (gigagram per year)	26,800.18	N.O.	0.19
ALL ENERGY	26,647.92	N.O.	N.O.
Fuel Combustion			
Energy and transformation industries	12,989.64		N.O.
Industry	8,922.33		
Transport	4,099.99		
Commercial-institutional	327.79		
Residential	308.17		
Biomass burned for energy		N.O.	
Fugitive Fuel Emission			
Oil and natural gas systems		N.O.	
Coal mining		N.O.	
INDUSTRIAL PROCESSES	N.O.		N.O.
AGRICULTURE		N.O.	N.O.
LAND USE CHANGE AND FORESTRY	N.O.		
WASTE	152.26	N.O.	0.19
Solid waste disposal on land	N.O.	N.O.	N.O.
Wastewater handling	N.O.	N.O.	0.19
Waste incineration	152.26	N.O.	N.O.
Memo Items:			
International Bunker Fuels			
Aviation	3,279.40		
Marine	3,198.33		

Note: N.O. – Not Occurring

Table 1:
1994 GHG Inventory.

The vulnerabilities identified are not attributed solely to climate change, but can be aggravated by adverse global climate change. As global climate change is very much beyond Singapore's control, the country has adopted a pragmatic approach of taking precautionary measures and establishing national systems to monitor and manage such vulnerabilities.

Mitigation

Singapore has developed many policies and implemented many measures that have helped to mitigate the increase in greenhouse gas emissions. The major initiatives are:

- Liberalisation of the Energy Sector
  Liberalisation of the energy sector started in 1995. The aim of liberalisation is to promote competition which will in turn lead to a more efficient energy sector.
- Changing Fuel Mix
  Singapore is trying very hard to move away from heavy reliance on fuel oil towards greater use of natural gas. The constraint is the availability of secure and reliable gas supplies. Recently, Singapore companies entered into gas supply agreements with Indonesia for the supply of 675 million standard cubic feet per day. The agreements provided for supply of gas to be stepped up gradually over time.
- Supply-side Management – Power Generation Efficiency
  Although power generation efficiency in Singapore has been high, new technologies such as the combined cycle gas turbine (CCGT) offer the opportunity for further improvement. A generating company has already converted some of its gas turbines into CCGT plants. More conversions are expected. Companies can also be expected to take advantage of the greater efficiency of co-generation technologies in the new competitive environment.
- Demand-side Management
  While intense global competition ensures that the industrial sector uses energy efficiently, companies are also encouraged to adopt energy-efficient technologies and acquire equipment through tax incentives and, in the case of small and medium-sized enterprises, partial financial grants for consultancy studies.

  For the building sector, the regulatory requirements on energy efficiency at the design stage are being reviewed and a post-construction performance requirement is being developed. The Housing and Development Board (HDB), which provides housing for 86 percent of Singapore's population, designs and builds its apartments to make better use of natural ventilation and

energy-conserving building services. HDB estates are also designed to minimise inter-estate transportation needs by integrating amenities and services and providing pedestrian-friendly features such as covered walkways between bus stops and apartments.

Energy efficiency for land transport is achieved by minimising the need to travel, providing good public transportation and minimising road congestion by implementing a vehicle quota system and an electronic road pricing system.

- Public Awareness and Education Programme
  The power-generating companies conduct regular educational programmes and training courses for industries and students as well as educate the general public through films, video shows, publicity leaflets and static and working displays on energy conservation. The Public Utilities Board provides energy audit services and advice on energy conservation measures for the industrial and commercial sectors, and encourages them to set up energy monitoring systems. There are also various agencies that organise seminars and workshops on energy efficiency.

  The Singapore Environment Council (SEC), a non-government organisation, administers a voluntary Green Labelling Scheme (GLS) and encourages consumers to purchase products carrying GLS labels. Energy consumption is a criterion for GLS products.
- Energy Recovery from Waste
  Singapore has a comprehensive management system to handle solid waste and wastewater and to recover energy from waste treatment. Organic solid waste is incinerated and the heat produced is used to generate electricity. Biogas produced during wastewater treatment is also used to generate electricity.

Renewable Energies

There are no hydro or geothermal energy sources that Singapore can harness. However, Singapore keeps a close watch on technological developments in various other forms of renewable energy and hopes to tap renewable energy on a large scale and in a commercially viable manner when the technology has been developed. A number of institutions have embarked on some applied research and pilot projects on solar energy use. Some commercial facilities and private homes already use solar heating to produce hot water. A notable example is the Flight Kitchen Building at Changi International Airport which uses solar heating to produce 2,500 kWh of heat per day to meet its hot water requirements.

Chapter 1

Country Circumstances

The Land

Singapore consists of one main island and some 60 smaller ones. It is located between latitudes 1° 09′N and 1° 29′N and between longitudes 103° 36′E and 104° 25′E, approximately 137 kilometres north of the Equator. It is separated from Peninsular Malaysia by the Straits of Johor and from the Riau islands of Indonesia by the Straits of Singapore.

The main island of Singapore is about 42 kilometres from east to west and 23 kilometres from north to south and has a coastline of 150 kilometres. The total land area (including that of the smaller islands) is 647.5 square kilometres. Among the islands, the larger ones are Pulau Tekong (24.4 square kilometres), Pulau Ubin (10.2 square kilometres) and Sentosa (3.5 square kilometres).

Singapore is a highly urbanised city-state.

Topography

Singapore's undulating surface reaches only 163 metres at its highest point. Much of the island is less than 15 metres above sea level. Granite and other igneous rocks in the centre of the island form a landscape of rounded hills and gentle spurs and valleys. To the west and southwest of the island, sedimentary rocks give rise to a series of narrow ridges, generally aligning northwest/southeast, which can be quite steep locally. The coast is generally flat. There is a considerable stretch of the coastline that has been markedly modified by reclamation work, building of embankments and redevelopment.

Climate

Singapore is an equatorial country with relatively uniform temperature, abundant rainfall and high humidity. The average daily temperature is 26.8°C, with the average daily maximum of 30.9°C occurring in the afternoon and the minimum of 23.9°C around dawn. December and January are generally the coolest months.

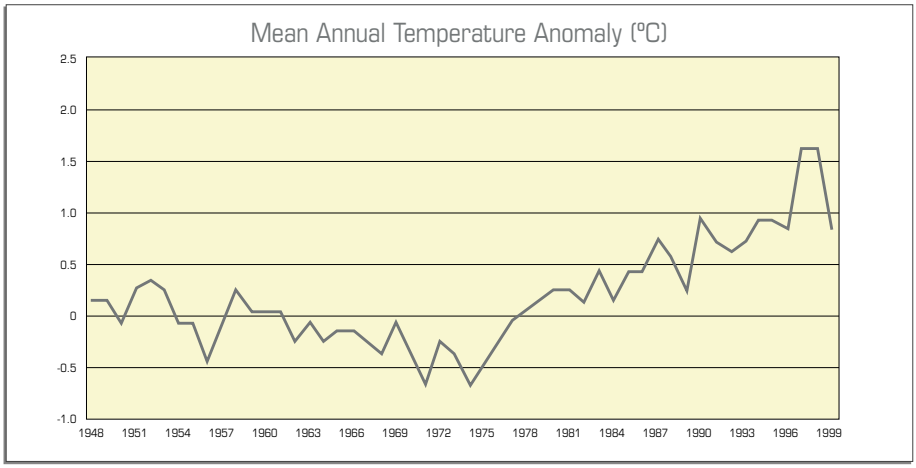
With an annual rainfall of 2,344 millimetres, rain is felt throughout the year but tends to be heaviest from November to January. July is usually the month with the lowest average rainfall. The relatively wetter Northeast Monsoon season is from December to March, while the drier Southwest Monsoon season is from June to September. Afternoon showers and thunderstorms are frequent during the inter-monsoon seasons in April-May and October-November. February is usually the sunniest month, while December is often the month with the least sunshine.

Relative humidity often exceeds 90 percent at night and in the early hours of the morning, shortly before sunrise. On dry afternoons, it is usually between 60 and 70 percent. The average daily relative humidity is 84.3 percent.

Climatological Statistics

Mean daily temperature	26.8°C
Mean daily maximum temperature	30.9°C
Mean daily minimum temperature	23.9°C
Highest maximum temperature	36.0°C
Lowest minimum temperature	19.4°C
Mean daily relative humidity	84.3%
Mean daily maximum relative humidity	96.1%
Mean daily minimum relative humidity	64.1%
Extreme minimum relative humidity	33.0%
Mean annual rainfall	2,344.0 mm
Highest annual rainfall	3,452.4 mm
Lowest annual rainfall	1,483.9 mm

There are year-to-year variations of the main weather elements as well as observed long-term climatic variations. For example, analysis of the mean annual temperature in Singapore indicates a general warming trend from around 1974 onwards as can be seen from the graph below. In 1999, however, the mean temperature fell slightly.



Source: Meteorological Service, Singapore

The trend appears to be consistent with global trend. However, it is still unclear as to whether this is due to the greenhouse effect or due to the natural variability of climate.

Water Resources

About 6 percent of the main island of Singapore has been set aside as protected water catchments. This comprises the central water catchments of Seletar, Upper Peirce, Lower Peirce and MacRitchie. In these protected water catchments, development is not allowed. A large portion of the catchment areas has been gazetted as nature reserves for conservation.

In addition, some 40 percent of land comprising the catchments of Kranji, Pandan, Sarimbun, Murai, Tengeh, Poyan, Seletar Streams, Lower Seletar, Bedok and Jurong Lake are also developed as unprotected water catchment areas. The level and type of development in these unprotected water catchments are controlled. All residential and industrial developments in these areas are served by public sewers. Only clean industries are sited within these water catchments.

Singapore has only a few small rivers. The built-up areas are well served by drainage channels to prevent flooding. The network of drains, canals, streams and rivers in the water catchments leads directly or indirectly via storm-water collection systems to reservoirs where raw water is stored. The raw water from the reservoirs has impurities such as suspended solids and dissolved minerals. This water is treated at water treatment works to potable water standards before it is conveyed to consumers' premises. Potable water is available to all parts of Singapore through an extensive water supply network. The quality of our potable water is well within the WHO Guidelines for Drinking Water Quality.

Water from non-catchment areas drains into the sea.

Agriculture, Fishery, Horticulture and Forestry

Agriculture is of very limited significance to the Singapore economy, representing only about 0.1 percent of GDP, estimated at S$141 billion in 1998. Agricultural products include vegetables, eggs, fish, milk, ornamentals (namely, orchids and other ornamental plants) and ornamental fish. Approximately 90 percent of the food consumed in Singapore is imported. In 1998, the value of the total supply of primary produce was S$2 billion.

Singapore aims to develop the limited agricultural and fishery areas to produce prime quality food and to serve as benchmarks on quality and pricing for imports and exports (i.e., export of ornamental fish and plants). This is an integral part of the overall food policy of ensuring a stable and adequate supply of safe, wholesome and quality meat, fruits and vegetables in Singapore. The Agri-food

High-tech agro-technology is used to optimise resources and increase yield.

and Veterinary Authority[3] (AVA) is the national authority dedicated to safeguarding the health of people, animals, fish and plants through advanced technology in agriculture, fisheries and veterinary science.

With limited land and sea resources for primary produce, Singapore's agricultural developments take place mainly in allocated areas, called Agrotechnology Parks on land and Marine Parks at sea. These parks are developed and managed by the AVA, and cover a total of 2,000 hectares, with 1,500 hectares for Agrotechnology Park development and 500 hectares for Marine Park development. Agrotechnology is the application of modern science and technology in large-scale, intensive farming to optimise use of resources and increase yield and productivity on the farm. In the long term, Singapore hopes to become an agrotechnology centre focusing on tropical and urban agriculture.

There are six Agrotechnology Parks, with 441 farms occupying some 1,034 hectares (1998 figures) and producing vegetables, eggs, fish, milk, as well as ornamental plants and fish. The parks have a mix of farms to minimise spread of disease specific to a single type of species of plant or animal and to minimise environmental impact and pollution. A 10-hectare Agri-Bio Park dedicated to agri-biotechnology investments has been established.

The Marine Parks are for marine fish farming. There are five Marine Parks with 90 floating fish farms producing both finfish and shellfish. The AVA regulates the number of floating farms in each

[3] The Agri-food and Veterinary Authority, a statutory board, was formed on 1 April 2000. Its predecessor was the Primary Production Department (PPD) under the Ministry of National Development (MND).

park to prevent water stagnation and poor water quality within the farming sites. The agricultural products, with the exception of the ornamentals, are destined for domestic consumption.

Agricultural activities in Singapore can be broadly classified into 12 categories, viz.,

- Foodfish:
  - (1) Foodfish production in floating cages at sea;
  - (2) Foodfish production on land-based ponds/tanks;
  - (3) Ornamental fish production in ponds/tanks;
- Animals:
  - (4) Hen's egg production;
  - (5) Production of ducks, quails and other game birds;
  - (6) Farming of dairy cattle and goats;
  - (7) Farming of frogs and crocodiles;
  - (8) Breeding of exotic birds.
- Plants:
  - (9) Vegetable production;
  - (10) Fruit growing;
  - (11) Orchid and ornamental plant production; and
  - (12) Aquatic plant production.

The agriculture policy was established in 1985 to develop sustainable urban agriculture with minimum impact on the environment.

Singapore has some 2,100 hectares of forests, safeguarded as nature reserves. The forests of Singapore are not commercially exploited for timber or other timber products nor are there any indigenous people dependent on the forests of Singapore for their subsistence. The natural areas of Singapore are, hence, conserved primarily for ecological, educational, recreational and scientific purposes. A biological survey completed in 1997, confirmed that the forest is species-rich, with 44 species of mammals, 127 species of resident birds, 72 species of reptiles and 25 amphibian species recorded. The nature reserves are actively managed, with emphasis on reforesting degraded areas. There is also a programme to gradually re-introduce indigenous species of flora and fauna back into the forests.

Although we do not have a national forest programme as understood in the normal context, 19 nature areas that represent different ecosystems in Singapore have been identified for conservation. Action programmes have been implemented to survey their biodiversity and monitor their health status. There is a mechanism whereby nature conservation considerations are incorporated into the planning and development processes. The 19 nature areas (including the nature reserves) total about 3,100 hectares or about 5 percent of Singapore's land area.

The greening of Singapore is a key objective of the government

in view of rapid urbanisation. Open spaces, parks, gardens, street plants and a network of green links are increasingly introduced into the urban environment. Besides the ongoing effort to plant trees in parks, open spaces and along roads, there are regulations requiring the conservation of mature trees, the setting aside of private lands for green buffers and the greening of open carparks.

Some 940,000 trees and more than 8 million shrubs have been planted in public spaces islandwide since 1963 when the "Tree Planting" campaign was launched, earning Singapore the name of Garden City.

Land Use

Singapore has an integrated land-use planning and management system. It developed its first Concept Plan in 1971. The strategic Concept Plan balances land needs and constraints. It includes provisions for long-term land uses such as housing and infrastructure as well as development strategies. The Concept Plan is then translated into a detailed Master Plan, which indicates land use on every plot of land. Development control decisions are guided by the Master Plan. The Concept Plan, the Master Plan and development control are all handled by a single agency, the Urban Redevelopment Authority (URA). This integrated approach ensures consistency, transparency and long-term sustainability with regard to land use.

Co-ordination between responsible bodies for land planning and management is facilitated by various standing committees and panels. Some examples are:

- Master Plan Committee
  Members include Ministry of the Environment, National Parks Board, Ministry of Defence, Land Transport Authority, etc. The committee considers and co-ordinates public-sector development proposals and resolves conflicts in land use among the public agencies.
- Waterbody Design Panel
  Members from various agencies work to enhance the aesthetic and recreational potential of waterways, e.g., turning canals running through urbanised areas into richly landscaped rivers, thereby enhancing the overall environment.

The URA works with various agencies when preparing and reviewing the Concept Plan and Master Plan. Comments and suggestions from the public are sought at different stages of the land-use planning process. Before the gazette of the Master Plan, a public exhibition is held to obtain feedback and suggestions from the public. These are incorporated into the plan where possible. The URA Development Control Division has frequent dialogues with professional bodies to review rules and guidelines.

Population

As at June 1998, the resident population, comprising Singapore citizens and permanent residents is estimated at 3.2 million, made up of 77 percent Chinese, 14 percent Malay, 7.6 percent Indian and a small percentage of other races. The total population, which includes foreigners holding work permits and employment passes working in Singapore, is estimated at 3.9 million.

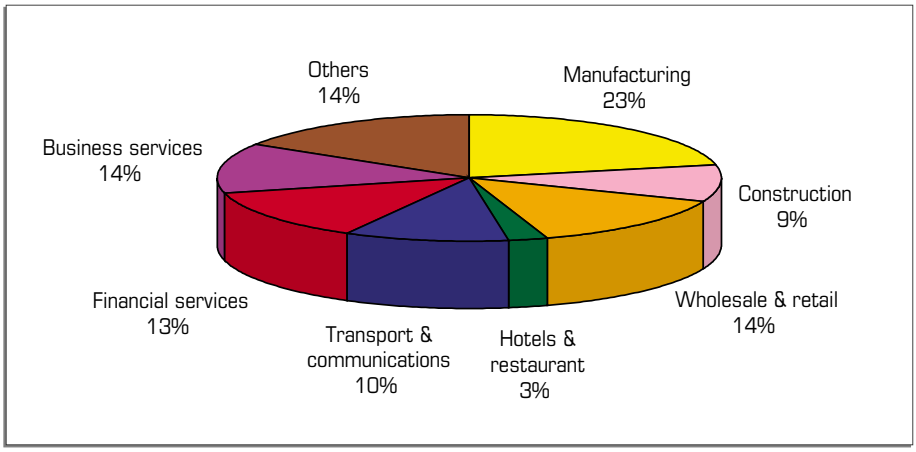
Singapore's resident population is multi-racial.

Economy and Development

Singapore is a young nation. Prior to 1960, Singapore's economy depended largely on entrepot trade. From a very modest beginning, Singapore rapidly developed its industrial base which today comprises high technology and high value added industries. A comprehensive housing and urban development programme accompanied economic growth. Over the past decades, Singapore has managed to build up a strong economy. Since 1965, its population has increased by about two folds (resident population by 1.6 times, and total population by two times), while Gross National Product (GNP), GNP per capita and total trade have increased by 49 times, 24 times and 52 times, respectively. Unemployment had also fallen from about 8.2 percent in 1970 to 3.2 percent in 1998.

As a result of efforts to industrialise and globalise the economy, our economic structure has changed over the years. The manufacturing sector had become a significant part of the economy, rising from a 15 percent share of GDP in 1965 to 23 percent in 1998. The financial services and business services sectors had also expanded to represent 13 percent and 14 percent of GDP in 1998, up from 4.2 percent and 9.0 percent respectively in 1965.

Meanwhile, the share of the wholesale and retail sector had declined from 23 percent in 1965 to 14 percent in 1998. Singapore's economic structure in 1998 is as follows:



Singapore's economic structure in 1998.

Phases of Development

Prior and soon after its independence, Singapore, with a young and unskilled work force, was faced with massive unemployment and inadequate infrastructure. The unemployment rate was standing at around 10 percent. The priority in the sixties was to create jobs and employment. Labour-intensive industries and operations, especially export-oriented types such as textile and garments, timber and wood products, simple assembly of electrical and electronic products, were attracted to provide employment and to build a foundation for our manufacturing industry. Infrastructural projects were also actively planned and implemented.

As unemployment was gradually reduced and stabilised, more capital-intensive industries such as petroleum refining, integrated circuits and more complicated assembly of electronic products were attracted to Singapore in the seventies. During this period, manufacturing-related services began to develop as more skilled labour was being trained and upgraded.

In the early eighties, the quality of Singapore's manpower was greatly improved and more high quality services were established. However, regional and international competition was growing while Singapore's operating costs were slowly increasing. To cope with these challenges, Singapore focused on attracting skill-intensive industries. These included industries manufacturing hard-disk drives, high-density drives (HDD) and other personal computer peripherals as well as fine chemicals.

In the nineties, the skill and quality of Singapore's manpower was further upgraded. More manufacturing-related supporting industries and services were established to support the various high-technology and skill-intensive multinational companies and

corporations in Singapore. Further increases in operating costs caused some small and medium-sized industries in Singapore to venture into neighbouring countries in search of cheaper resources.

When other Southeast Asian nations and China started to further liberalise their trade and investment policies, the trend of international division of labour began to emerge. In response to the new trend and its resultant needs, Singapore began to build a "second wing" for its economy by establishing industrial parks in countries such as China, Vietnam, India, Thailand and the Philippines for Singapore's industries as well as other multinational companies.

Technological advances and globalisation have been gathering pace, and countries no longer compete with one another within a region but globally. Knowledge has increasingly become a strategic asset for economic growth and for survival in the 21st century. To maintain our lead in this knowledge-based economy, the strategy for this new century is to make better use of the knowledge that Singapore has accumulated as well new knowledge to be learned to further upgrade and strengthen our economy and improve our living environment. More innovative ideas, products, industries and services will be encouraged to find their niches in the Singapore economy.

Environmental Management

For more than 30 years, Singapore has based its environmental policies on the principle of balancing development and the environment. It will continue to treat economic competitiveness and environmental sustainability as two sides of the same coin. They are complementary aspects of the common goal of a healthy economy with a clean living environment.

The success of its environmental protection measures is evident today. Singapore has an environment that is clean and green. The levels of pollutants in our ambient air are within the WHO and USEPA standards. The inland waters support aquatic life and the coastal waters meet recreational water standards. Singapore today has a high environmental public health standard. The average life expectancy is 77 years and the infant mortality rate has declined to about 4 per thousand live-births. The infectious disease situation is well under control.

One key feature of Singapore's environmental protection programme is our belief that prevention is better than cure. Prevention of environmental degradation calls for careful land-use planning and extensive infrastructural development. Second, it has adopted the "Polluter Pays Principle" whereby a polluter bears the cost of mitigating pollution. A third feature is the close monitoring of air

and water quality and pre-emptive action taken quickly if there are risks of pollution. Fourth, there are comprehensive pollution control laws that are enforced in a stringent manner.

Planning Control

Proper land-use planning is critical for pollution prevention. Industries are sited adequately away from population centres and from water catchments. The impact of new developments on the environment is carefully assessed before they are allowed to proceed. This includes an assessment of their pollution impact to ensure that prospective industries do not pose any major health and safety hazards or pollution problems. A proposed industry will be allowed only if its emission of pollutants can comply with the prescribed standards, its wastes can be safely managed and properly disposed of, and it is sited in a suitable industrial estate.

Environmental Infrastructure

Over the years, heavy investments have been made in environmental infrastructure to prevent pollution. Two examples are the sewerage system and the solid-waste management system.

Singapore's Ministry of the Environment (ENV) has a programme to provide a comprehensive sewerage system that keeps pace with new industrial, housing and commercial developments. Today, all wastewater is collected and treated before discharge into the sea. Some S$2.5 billion have been invested in more than 2,500 kilometres of sewers, 139 pumping stations and six sewage treatment works.

ENV is also embarking on the Deep Tunnel Sewerage System (DTSS), a network of deep tunnels to intercept sewage flows in the

Refuse incinerator plants are part of the comprehensive environmental infrastructure Singapore has invested in.

existing sewerage reticulation system, which comprises gravity sewers and pumping installations, and to channel these sewage flows to two new centralised sewage treatment works. The treated effluent will be discharged through deep sea outfalls into the Straits of Singapore and the South China Sea.

Singapore has a comprehensive refuse collection system that has been fine-tuned over the years. All solid wastes are collected and disposed of promptly. Owing to land constraints, Singapore has chosen incineration as the disposal method to help conserve the limited capacity of its sanitary landfill. All incinerable wastes are burnt at four modern incineration plants, the fourth plant having been commissioned in 2000. The incineration plants are fitted with flue gas cleaning devices and their emissions are monitored closely. Energy is recovered to generate electricity. Scrap metal is also recovered. In addition, efforts are made to encourage the population to conserve resources and adopt a less wasteful lifestyle to minimise waste generation.

"Polluter Pays Principle"

Homes and industries have to pay a wastewater collection and treatment levy (known as the "water-borne fee") for each cubic metre of water used. The levy is based on the cost of collection and treatment of wastewater. Non-residential premises have to pay for refuse removal based on a quantity-based schedule of fees. Therefore, the more wastewater and solid waste one generates the more one pays towards the treatment of these wastes.

Monitoring and Enforcement

Routine monitoring of the ambient air, inland and coastal waters is carried out to assess the adequacy and effectiveness of the control programmes in maintaining a clean and healthy environment. Signs of deterioration are quickly picked up and investigated. This allows pre-emptive action to be taken quickly before our air or water quality is adversely affected.

Comprehensive preventive measures to safeguard the environment will not work unless there is stringent enforcement to ensure that the laws and regulations are complied with. Officers from ENV carry out regular surveillance and inspection to make sure that pollution is kept in check. Where pollution does take place, enforcement action is taken promptly.

The Singapore Green Plan

There is a clear vision of what the country wants to achieve in the long term and this vision is described in the Singapore Green Plan, the national blue-print on the environment. Singapore aims to be a city with a clean living environment and high standards of

public health as well as a city whose people care for and take a personal interest in both the local and the global environment.

Institutional Arrangements to Manage Climate Change

Singapore has, within its resources, been participating actively in the UNFCCC process and doing its part to protect the global environment. Singapore recognises that climate change is a highly complex issue that cannot be addressed by a single agency alone and has, therefore, set up an institutional arrangement to manage it. It has adopted a decentralised approach in which the respective agencies take the lead for developing appropriate responses to matters concerning them, while ENV acts as the national focal point for the UNFCCC.

As climate change issues are cross-sectoral, ENV has also formed an Inter-agency Committee on Climate Change (IACCC) to address climate change issues, including the preparation of the initial national communication. The IACCC is chaired by ENV with participation from:

- Ministry of Foreign Affairs;
- Ministry of National Development;
- Ministry of Communications and Information Technology;
- Ministry of Trade and Industry;
- Trade Development Board;
- Economic Development Board; and
- Department of Statistics.

This initial national communication has been prepared by the IACCC.

Singapore has a 150-kilometre coastline.

Factors Contributing to Greenhouse Gas Emissions

Singapore's main greenhouse gas emissions are carbon dioxide (CO_2). The main factors contributing to CO_2 emissions are:

- energy production to meet industrialisation and economic development needs;
- increased consumption of energy due to increasing standard of living, application of Information Technology in homes and workplaces; and
- increase in population.

With further industrialisation and development taking place and improving standard of living and consequent energy consumption, the emission of greenhouse gases is expected to increase.

Special Considerations under Article 4.8 of UNFCCC

Article 4.8 of the UNFCCC states that Parties shall give full consideration to actions to meet the specific needs and concerns of developing country Parties arising from the adverse effects of climate change and /or the impact of the implementation of responsive measures. Three sub-clauses in the article are of specific relevance to Singapore, namely:

- Small island countries;
- Countries with low-lying coastal areas; and
- Countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products.

Being a small island country with low-lying coastal areas, Singapore is vulnerable to changes in sea level. The manner Singapore deals with rising sea level due to climate change is dealt with in Chapter 3.

Singapore lacks natural resources and is totally dependent on imported fossil fuels to power its economy.

To date, there are no renewable energy sources that Singapore can harness to reduce its reliance on fossil fuels. It does not have hydro and geothermal energy sources. Nuclear energy cannot be used due to geo-political and safety concerns. Calm seas and lack of sea space mean that it cannot tap wave energy. Neither does it have the land to cultivate biomass as an energy source. Wind energy has limited potential due to lack of land to establish wind farms and the relatively low wind speed.

The only known source of renewable energy with some potential for use is solar energy. However, technology is still some way off in making solar energy a commercially viable source of energy, and Singapore's small land area presents a limit on the potential of this source. In the absence of alternative energy sources,

Singapore has to rely mainly on fossil fuels for primary activities such as power generation and transportation.

The only means available to Singapore to mitigate GHG emissions is to use energy as efficiently as is practically possible. The measures it has undertaken to do so are detailed in Chapter 4. It has also done all it can to plant as many trees and plants as possible within its very limited land area. This has helped to create some carbon sinks, albeit very small ones relative to those created by other countries endowed with large expanses of land. Singapore is thus at a great disadvantage in not being able to offset its GHG emissions with carbon sinks.

Chapter 2

National Greenhouse Gas Inventory

Singapore's economy is driven by financial and business services, manufacturing, construction, transport and communications, and other sectors such as the wholesale and retail sector. The agricultural sector is very small and is focused mainly on produce such as eggs, fish and vegetables for local consumption, and orchids and ornamental fish for export. Land-use change is insignificant as most parts of the country have been developed, except for the central forest area which is a protected water catchment. The only significant GHG emissions in Singapore are carbon dioxide. GHG emissions from agriculture, and land-use change and forestry sectors are negligible.

Methodology Used

Singapore's emission estimates for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are computed using the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

The reference and sectoral approaches were used to establish the 1994 greenhouse gas inventory for the energy sector. The sectoral approach has been used as the basis for our inventory. In accordance with the IPCC guidelines, emissions from international aviation and marine bunker fuels are excluded from the overall greenhouse gas inventory. These emission data are reported separately under the category "memo items" provided under the IPCC guidelines.

Our 1994 Emissions

Our CO_2 emissions for 1994 totalled 26,800 gigagrams of CO_2-equivalent. The energy sector accounted for 99 percent of the total emissions. The remaining 1 percent is from the waste sector, where the estimate of nitrous oxide (N_2O) emitted was converted to CO_2-equivalent based on N_2O's global warming potential of 320 over a 100-year time horizon. A breakdown of our total greenhouse gas emissions by sources is shown in Table 1.

Energy Sector

The combustion of fossil fuels is the major source of carbon dioxide emissions in Singapore. Both the Revised 1996 IPCC Guidelines' reference and sectoral approaches were used in the estimation of the greenhouse gas emissions from the energy sector. The estimates were made using the default conversion and emission factors provided in the IPCC guidelines. The statistical difference in the figures obtained from the two approaches is primarily due to uncertainties in conversion factors, stock change and estimation of stored carbon in the reference approach. The amount of CO_2 emitted from the energy sector in 1994 totalled 26,647.92 gigagrams.

Emissions from electricity generation and the manufacturing industries accounted for 48.7 percent and 33.5 percent of the total CO_2 emissions respectively. Emissions from transport contributed 15.4 percent. The commercial and residential sources accounted for 2.4 percent.

Greenhouse Gas Source and Sink Categories	CO_2	CH_4	N_2O
Total (Net) National Emission (Gigagram per year)	26,800.18	N.O.	0.19
ALL ENERGY	26,647.92	N.O.	N.O.
Fuel Combustion			
Energy and transformation industries	12,989.64		N.O.
Industry	8,922.33		
Transport	4,099.99		
Commercial-institutional	327.79		
Residential	308.17		
Biomass burned for energy		N.O.	
Fugitive Fuel Emission			
Oil and natural gas systems		N.O.	
Coal mining		N.O.	
INDUSTRIAL PROCESSES	N.O.		N.O.
AGRICULTURE		N.O.	N.O.
LAND USE CHANGE AND FORESTRY	N.O.		
WASTE	152.26	N.O.	0.19
Solid waste disposal on land	N.O.	N.O.	N.O.
Wastewater handling	N.O.	N.O.	0.19
Waste incineration	152.26	N.O.	N.O.
Memo Items:			
International Bunker Fuels			
Aviation	3,279.40		
Marine	3,198.33		

Note: N.O. – Not Occurring

Table 1:
Initial National Greenhouse Gas Inventories of Anthropogenic Emissions by Sources and Removals by Sinks of all Greenhouse Gases not Controlled by the Montreal Protocol.

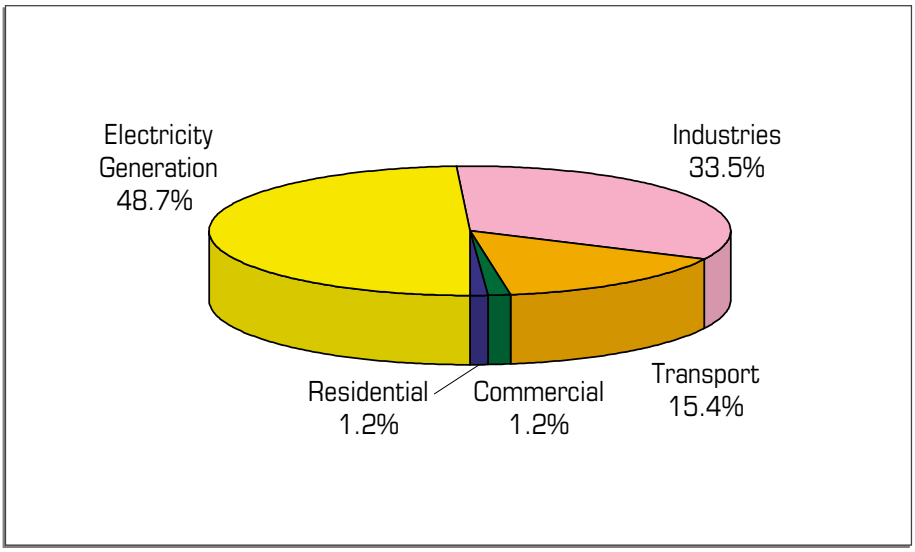


Chart 1:
Contribution of CO_2 emissions from various sources in the energy sector.

Electricity Generation

In 1994, the total quantity of fuel used for the generation of 20,675.6 million kWh of electricity was 4.58 million tonnes of fuel oil equivalent (including 55,261 million standard cubic feet of natural gas).

The total amount of carbon dioxide emitted from electricity generation was 12,989.64 gigagrams. Fuel oil and diesel accounted for 74 percent of the emissions and natural gas the remaining 26 percent.

For the year, sale of electricity amounted to 18,901.3 million kWh. The manufacturing sector was the single largest user of electricity (45 percent), followed by other industries (37 percent) and the domestic (18 percent) sectors.

Industries

Singapore does not produce any oil or gas. It is, however, a major oil refining and petrochemical centre and imports crude oil from the Middle East and other oil producers. The oil refinery and petrochemical industries accounted for 7,026.08 gigagrams of CO_2 emission and the other industries emitted 1,896.25 gigagrams.

Energy-efficient technology is used for power generation – A combined-cycle gas turbine plant at Senoko Power Station. (Picture courtesy of Power Senoko Ltd.)

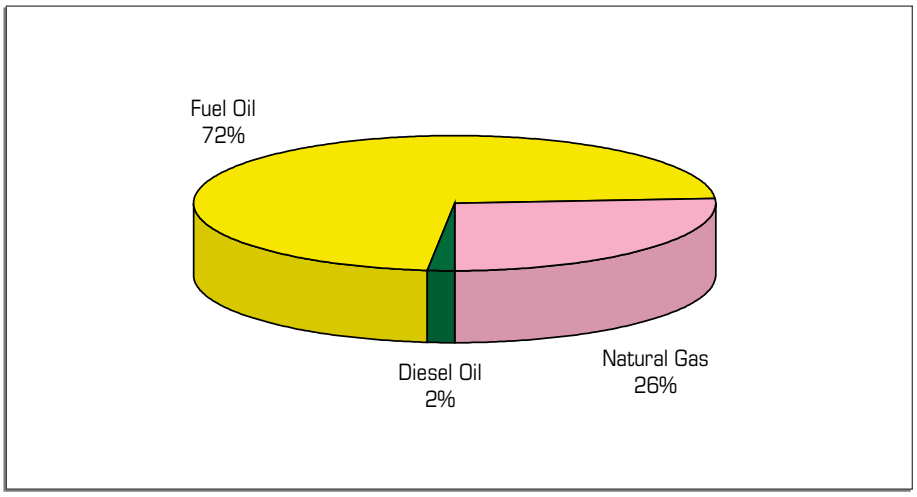


Chart 2: Contribution of CO_2 emissions from different types of fuel used for electricity generation.

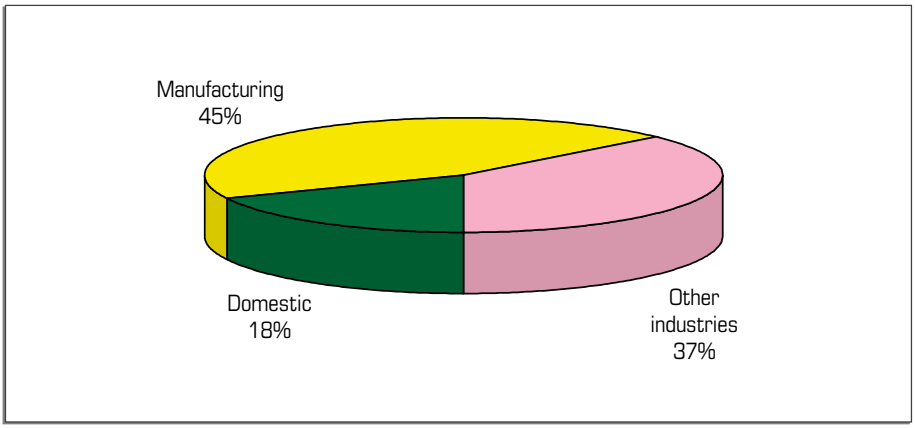


Chart 3:
Sale of electricity in 1994.

A petro-chemical plant.
(Picture courtesy of Eastman Chemical Singapore Pte. Ltd.)

Transport

Land transport accounted for 15.4 percent of the total CO_2 emissions from the energy sector. In 1994, Singapore had a network of 3,027 kilometres of public roads and a population of 611,600 motor vehicles. Diesel and petrol were the only fuels used by these motor vehicles. These vehicles consumed 682.1 kilo-tonnes of diesel and 628.9 kilo-tonnes of petrol for the year, contributing 4,099.99 gigagrams of CO_2 to the total emissions.

Commercial and Residential

Commercial and residential premises contributed only 2.4 percent of the total CO_2 emissions. These were from the use of liquefied petroleum gas (LPG) and town gas, mainly for cooking and hot water systems. In 1994, 1,045.8 million kWh of town gas and 145 kilo-tonnes of LPG were consumed. This was equivalent to 327.8 gigagrams of CO_2 emissions.

Industrial Processes Sector

The cement manufacturing industry in Singapore produced cement from imported clinkers. There were, therefore, no CO_2 emissions from the cement production process.

In the oil refining industry, CO_2 was produced in the hydrogen manufacturing and catalytic cracking processes. The emissions in 1994 were estimated to be 567.55 gigagram of CO_2. This was not reflected in the national inventory.

Waste Sector

Greenhouse gas emissions from the waste sector in Singapore are categorised as follow:

- Waste incineration;
- Managed solid waste disposal sites; and
- Wastewater handling.

For 1994, the greenhouse gas emissions from the waste sector is summarised below.

Greenhouse Gas Source	Greenhouse Gas Emissions (Gg)		
	CO_2	CH_4	N_2O
Waste incineration	152.26	–	–
Managed solid waste disposal sites	–	–	–
Wastewater handling	–	–	0.19

Waste Incineration

According to the IPCC guidelines, CO_2 emissions from waste incineration are to be estimated from the portion of the waste that is fossil fuels based and exclude the biomass fraction. The average carbon content of the waste incinerated in 1994 was 23 percent and the plastic content was 10.2 percent. Waste incineration was estimated to have contributed 152.26 gigagrams of CO_2 to the total greenhouse gas emissions in 1994.

Solid Waste Disposal Sites

Our solid waste management infrastructure in 1994 consisted of three incineration plants and two sanitary landfills. In Singapore, all organic wastes are incinerated at the incineration plants and only non-incinerables and ashes from incineration of wastes are disposed of at the landfills. Therefore, emission of CH_4 from landfill sites is insignificant.

Wastewater

In 1994, Singapore's sewerage facilities comprised a network of 2,450 kilometres of sewers and pumping mains, 134 pumping installations

A sewage treatment works where biogas is recovered to produce electricity.

and six sewage treatment works.All sewage and wastewater are discharged into sewers and treated at the sewage treatment works. An activated sludge process is used at all the six sewage treatment works and the sludge is stabilised in digesters.

For 1994, the sewage treatment works treated 314 million cubic metres of sewage and 20.19 million cubic metres of biogas (containing 41.4 percent CH_4) was produced.

The biogas produced was used as fuel to generate electricity to power the operation of the treatment facilities. Fugitive CH_4 emissions from leakage and flaring activity were negligible. Therefore, there was no significant CH_4 emissions from the wastewater handling activity.

A report[4] by the UN Food and Agriculture Organisation estimated Southeast Asia's protein intake to be 60 grams/capita/day. Using this as an estimate of Singapore's 1994 annual per capita protein intake, our estimated N_2O emission from human sewage is 0.19 gigagrams. Based on a 100-year time horizon, where N_2O has a global warming potential of 320, the amount of N_2O emission is equivalent to 60.8 gigagrams of CO_2.

Memo Items

Singapore, being a small island state, does not have domestic flights or domestic shipping services. Its strategic geographical

[4] The paper "Livestock production in the Asia and Pacific region – current status, issues and trends" was written by H. Steinfeld of the Food and Agriculture Organisation (FAO) and posted in the FAO webside: www.fao.org.

location has enabled Singapore to develop into a major air and sea transportation hub. Large volumes of aviation and marine bunker fuels are dispensed in Singapore for international routes.

The Singapore Trade Development Board captures the quantity of fuel supplied to foreign registered ships and aircraft for their own consumption as export figures. This is reported under export quantities in the preparation of the national inventories.

The quantities of aviation and marine bunker fuels dispensed to Singapore-registered aircraft and ships are much smaller than the export bunker fuels; but they are still significant. The bunker fuels are used for international routes and are reported separately as international bunker fuels.

Details of the quantities of bunker fuels for both export and as international bunker fuels are shown below.

Type of Bunker Fuels	Export (kt)	International Bunker Fuels (kt)
Aviation	941	1,039
Marine	14,294	1,039

Carbon Sink

Singapore has limited activities in land-use change and forestry. These activities do not produce significant carbon fluxes to and from the atmosphere. There is no forestry industry or plantation.

Notwithstanding the limited land we have, some 940,000 trees and more than 8 million shrubs have been planted in public places. This is part of the government's programme to provide a pleasant living environment in the city-state. These non-forest trees and shrubs constitute a sink for carbon sequestration, though a small one. In addition, there are 2,100 hectares of forests that are safeguarded as nature reserves, and are conserved primarily for ecological, educational, recreational and scientific purposes.

Uncertainty

Singapore's national inventory was assessed based on the three levels of confidence described in the Revised 1996 IPCC Guidelines. It is based on the judgement of those compiling the inventories rather than on quantitative analysis. Uncertainties in the estimates of the greenhouse gases are attributed mainly to the inadequate understanding of some of the processes used to estimate greenhouse gas emissions, conversion factors and incomplete data. The levels of confidence of inventory data are presented in Table 2.

Overview Table						
Greenhouse Gas Source and Sink Categories	CO_2		CH_4		N_2O	
	Estimate (Gg)	Quality[4]	Estimate (Gg)	Quality	Estimate (Gg)	Quality
Total National Emissions and Removals						
ALL ENERGY						
Fuel Combustion Activities						
Reference Approach	27,875.89	M				
Sectoral Approach	26,800.18	M				
1 Energy Industries	12,989.64	H				
2 Manufacturing Industries and Construction	8,922.33	M				
3 Transport	4,099.99	H				
4 Commercial and Residential	635.96	H				
Fugitive Emissions from Fuels						
1 Solid Fuels						
2 Oil and Natural Gas						
INDUSTRIAL PROCESSES						
SOLVENT AND OTHER PRODUCT USE						
AGRICULTURE						
LAND-USE CHANGE & FORESTRY						
WASTE						
Solid Waste Disposal on Land						
Wastewater Handling					0.19	M
Waste Incineration	152.26	M				
Memo Items:						
International Bunker Fuels						
Aviation	3,279.40	M				
Marine	3,198.33	M				

[4] Quality of GHG emission estimates: H – High confidence in estimation; M – Medium confidence in estimation; L – Low confidence in estimation

Table 2: Confidence levels of data.

Sources of Data

The 1994 greenhouse gas emissions were estimated from information obtained from the following publications/sources:

- Singapore Year Book of Trade Statistics (Import and Export) 1994, Trade Development Board;
- Monthly Digest of Statistics (March 1995), Department of Statistics;
- Annual Report of the Public Utilities Board (1994);
- Annual Report of the Ministry of the Environment (1994);
- Maritime & Port Authority of Singapore;
- Trade Development Board; and
- Activity data submitted by industries.

Structure of National Greenhouse Gas Inventory Compilation

Our national greenhouse gas inventory team develops Singapore's inventory through a four-stage process:

- Data collection and compilation;
- Checking of data input and greenhouse gas computation;
- Verification of greenhouse gas inventories; and
- Endorsement of national greenhouse gas inventories.

At each stage, the reliability of the source data and the accuracy of the data capture are subjected to review before the information is submitted to the next stage for processing. This minimises human errors during inventory compilation.

It is necessary to look into institutional strengthening and capacity building for future work on estimating greenhouse gas emissions. More training is needed for members of the inventory team in respect of data gathering and estimation of greenhouse gas emissions.

List of National Inventory Methodology Worksheets

The following revised 1996 IPCC methodology worksheets for the estimation of Singapore's greenhouse gas emissions for 1994 are appended in the Annex.

Worksheet	Description
1-1	CO_2 from energy sources (Reference Approach)
1-2	CO_2 from fuel combustion by source categories (Tier 1)
6-4	Indirect Nitrous Oxide Emissions from Human Sewage

Chapter 3

Vulnerability and Adaptation

A well-designed and maintained storm-water management system helps to minimise flooding.

Being a relatively low-lying, small island state in the tropics, Singapore is vulnerable to the following concerns arising from climate change:

- Land loss and coastal erosion;
- Loss of water resources;
- Flooding; and
- Public health impact from resurgence of diseases.

These vulnerabilities are not due solely to climate change, but can be aggravated by adverse global climate change. Singapore does not expect to face a severe and abrupt impact as global climate change will occur gradually over a long period of time and adaptation measures can be taken to mitigate the effect.

Of the four vulnerabilities identified, the first three are direct manifestations of a rise in sea level. The IPCC Working Group I has projected a rise in global sea level of 15 centimetres to 95 centimetres by 2100. Some preliminary examination of the impact of a rise in sea level of a metre on Singapore was carried out by the National University of Singapore[5]. The study observed that defensive action was the only strategy applicable to Singapore given the limited land areas. It suggested that the following need to be considered and more research has to be done:

- protective measures such as docks and dykes for populated and developed areas;
- protection of coastal reservoirs from salt water intrusion such as improved dykes; and
- protection from flooding through better tide gates and pumping systems.

[5] A paper "Impact of a sea level rise on the coasts of Singapore: Preliminary Observations" was published by P.P. Wong in Journal of Southeast Asian Earth Sciences, Vol. 7, No. 1, pp. 65-70,1992.

Land Loss and Coastal Erosion

Much of Singapore's land is less than 15 metres above sea level. The coastline, including the offshore islands, is about 150 kilometres long. Most parts of the coastline, including many of its offshore islands, have been modified over time through land reclamation. As part of its long-term development plan of land resources, the URA, which is the master planner of land resources in Singapore, will eventually be modifying the remaining natural coastlines. The issue of land loss and coastal erosion can be overcome by engineering treatment and proper maintenance of the coastlines and will be addressed when the need arises.

Most parts of the coastline are modified by reclamation where engineering techniques are used to prevent erosion.

Water Resources

Water is a strategic resource that Singapore has to guard zealously. About half of the land forms the water catchment and water is stored in 14 raw-water reservoirs. The estuaries of some of the larger rivers have been dammed to form reservoirs. The dams are designed to prevent seawater infiltration and a rise of sea level (up to 0.95 metres in 2100) will have very little impact. The tide gates which discharge surplus flood water from the coastal reservoirs into the sea are adequately designed. The operation of these gates will be closely monitored.

Singapore is not self-sufficient in fresh water. More than 50 percent of Singapore's potable water is imported from Malaysia. It is working with other countries on agreements to secure additional supplies to ensure that there will always be adequate water to meet its needs. It is also embarking on the development of desalination plants to increase its local supply. ENV is also

working with the PUB on water reclamation technologies to re-use sewage effluent for potable water purpose.

With strict pollution control measures to protect indigenous water sources, continuing efforts to secure additional external supplies and use of technology such as desalination, Singapore is confident that there will be enough potable water to meet its needs. From the water perspective, Singapore will, therefore, be able to adapt and meet the challenges imposed by climate change.

Half of the land, including this central catchment, is used to provide 50 percent of Singapore's water needs.

Flooding

Singapore has a tropical climate and high rainfall. The island is relatively flat. A storm-water management system has been put in place to ensure that storm-water runoff drains away quickly to minimise flooding and to prevent public health problems. The system is being improved continuously to keep up with land developments. A rise in sea level could make it more difficult for storm-water runoff to drain into the sea and this could aggravate inland flooding. The storm-water management system enables close monitoring of the storm-water drainage and flooding situation so that timely action can be taken to ensure that flooding will be minimised.

Over the years, through the construction and improvement

of drains and the raising of platform levels in the course of land development, flood-prone areas have been reduced considerably. A pumped drainage system is implemented where it is not possible to raise the platform level. In other low-lying areas, tide gates have been installed and operated to prevent water during extremely high tides from entering drains and inundating low-lying areas.

All new developments are required to have adequate drainage to prevent new flood-prone areas from forming and infrastructures such as road underpasses, MRT tunnels, etc., are provided with adequate flood protection measures. The entire drainage system is carefully maintained to prevent ponding of water and mosquito breeding, thereby taking care of potential public health problems.

Resurgence of Diseases

Climate change has been identified as one of the causes of change in the pattern of communicable diseases throughout the world. Singapore is situated in a region that is endemic to many communicable diseases. Its open economy and relatively mobile population increase the risk of exposure to communicable diseases. In addition, it has a very high population density per unit area, which makes it a challenge to contain the spread of communicable diseases. Therefore, any change in global communicable disease patterns will be a concern and the country has to be prepared to handle any resurgence of communicable diseases.

ENV is responsible for preventing the introduction and spread of infectious food-borne and vector-borne diseases. It administers a comprehensive infectious disease surveillance programme, under which all hospitals, clinics and laboratories must notify ENV on a number of these diseases. The strategy emphasises a well-established system of epidemiological surveillance that enables the source of an infectious disease to be identified and eliminated before it poses a threat to the population. Seroepidemiological surveys are also undertaken routinely to assess the level of herd immunity of the population and their risk to various infectious diseases.

Our defence against emerging and re-emerging diseases is to further strengthen the already well-established epidemiological surveillance system, to continue to improve the high standard of environmental sanitation and to collaborate with relevant bodies in research projects on the prevention and control of these diseases both within and outside Singapore.

Singapore formed the Institute of Environmental Epidemiology (IEE) in 1992 to promote a high standard of environmental

public health by harnessing the expertise and resources in environmental epidemiology of the government and universities. Since 1995, the IEE has been designated a WHO Collaborating Centre.

The other important strategy to manage diseases is to control vectors effectively. The main vectors are mosquitoes, flies, cockroaches and rodents. The approach taken is to institute a good surveillance system and an integrated control programme that consists of environmental management, health education, biological and chemical control and legislation.

The system that has been put in place to control and manage communicable diseases has been proven to be highly reliable. However, Singapore will continue to improve the system and adapt successfully to any adverse development in diseases caused by climate change.

In summary, Singapore is aware of its vulnerabilities that may be aggravated by climate change. Global climate change is very much beyond Singapore's control. It has, therefore, adopted a pragmatic approach of taking precautionary measures and establishing national systems to actively monitor and manage these vulnerabilities.

Chapter 4
Mitigation

Over the years, Singapore has developed many policies and implemented many measures that have helped to mitigate the increase in greenhouse gas emissions. The predominant greenhouse gas is carbon dioxide produced by the combustion of fossil fuels for both stationary and mobile use. This is so because of the total reliance of the economy on energy derived from fossil fuels.

Singapore has, therefore, focused its efforts in mitigating emissions arising from fossil fuels. The measures that have been undertaken are described in this chapter. In addition, it monitors developments in renewable energy closely and hopes to tap renewable energy on a large scale and in a commercially viable manner when the relevant technology has been developed.

Liberalisation of the Energy Sector

Traditionally, the electricity industry in Singapore had been vertically integrated and for more than 30 years, the Public Utilities Board (PUB), a statutory board, was responsible for generation, transmission and supply of electricity to consumers. The PUB was reconstituted on 1 October 1995 to take on its new role as a regulator for the electricity and piped-gas industries. Its main role is to protect consumers' interest in respect of reliability and pricing.

Since then, the electricity and gas departments of the PUB have been corporatised. The vertically integrated electricity industry has been restructured. Two generating companies, a transmission and distribution company and a supply company have been formed. The third generating company, Tuas Power, came on stream in the first quarter of 1999. In addition, SembCorp Cogen Pte Ltd has been granted a power-generation licence.

Restructuring was done to promote competition and to ensure that the industry remains efficient as the overall capacity grows over time. The rationale was that competition would effectively lead industry players to find innovative, least-cost solutions and make optimal use of new technologies, which lead to even higher power-generation efficiency.

The Singapore Electricity Pool (SEP) commenced operation on 1 April 1998. It is operated as a wholesale electricity market that allows trading of electricity between power-generation and supply companies in a competitive environment. Prices will be regulated for as long as there is no effective competition.

Fuel Mix

Singapore has been heavily reliant on oil as a fuel. Till 1992, fuel oil was the sole fuel for electricity generation. Singapore recognises that natural gas produces less carbon dioxide per unit of energy generated than oil and has been working towards greater use of natural

gas in place of fuel oil. Since 1992, part of the electricity production from the Senoko Power Station is fuelled by natural gas procured from Malaysia. The effort to switch to natural gas is mainly constrained by the availability of secure and reliable gas supplies. In this respect, much progress has been made recently.

A company called SembCorp Gas has signed an agreement with Pertamina (an Indonesian state-owned company) in January 1999 to import natural gas from West Natuna in Indonesia to Jurong Island in Singapore. The first gas delivery is expected to begin in the second quarter of 2001. Under the agreement, 325 million standard cubic feet per day (mscfd) will be delivered to Singapore.

In a separate development, negotiations are underway between Pertamina and Singapore Power to secure natural gas from Sumatran gas fields. Under this deal, Pertamina is likely to increase gas supplies to Singapore in stages with the initial contract starting at 150 mscfd in 2002. This will rise to 350 mscfd by 2008.

Supply-side Management – Power-Generation Efficiency

Power-generation efficiency in Singapore has been high. To illustrate, the "1992 World's Competitiveness Report" ranked Singapore second (marginally behind Denmark) in power-generation efficiency and reliability. For a conventional new medium-sized steam plant and combined cycle gas turbine (CCGT) plant, the generation efficiencies are of the order of 35-40 percent and 45-50 percent, respectively.

The advantage of CCGT technology is obvious. With the advancement of technology in recent years, combined cycle for power generation has proved to be reliable. PowerSenoko Ltd[6] has converted four 128 MW gas turbines into two 425 MW combined cycle plants. These plants have been in commercial operation since February 1997.

With the liberalisation of the electricity industry in Singapore, the power-generating companies' decision on generating technology will depend on market forces. CCGT technology and co-generation technologies with their higher efficiencies would gain favour in the new competitive environment. Co-generation could achieve an efficiency of up to 70 percent or more.

Already, there are indications that the power companies are operating their most efficient plants available while relegating the less efficient ones as standby units. When old plants are replaced or new capacity added the power companies could be expected to consider the more efficient power-generating technologies seriously. For

[6] PowerSenoko Ltd is one of the four power-generating companies in Singapore.

A co-generation plant of an oil refinery. (Picture courtesy of Shell Eastern Petroleum (Pte.) Ltd.)

instance, PowerSenoko is considering transforming its Stage I oil-fired steam plants, which have been operating since 1975, into 600 MW combined cycle plants when natural gas supply has been secured.

Demand-side Management

Our industrial sector operates in a highly competitive environment at the global level and the bulk of the output is for exports. This helps to ensure that energy is used efficiently. This is best illustrated by the efforts of some of the companies from different industries highlighted below.

NatSteel Ltd is the only steel producer in Singapore. Natsteel produces steel from scrap iron. Steel making is a very energy-intensive process and Natsteel is the second largest consumer of electricity in Singapore. To stay competitive, the company is always seeking out ways to use energy more efficiently. For example, in 1997, it commissioned a new shaft-type electric arc furnace. The new technology resulted in a saving of about 150 kWh per metric tonne of steel produced, a 33 percent reduction from 450 kWh per metric tonne needed previously. With an annual production of 600,000 tonnes, Natsteel saves 90 million kWh of electricity a year.

In 1995, Shell, operating Singapore's largest oil refinery, invested in a S$50 million co-generation plant that generates 24 MW of electricity and 56 tonnes of steam per hour, using fuel gas as the energy source. The plant achieves a combined efficiency of 77 percent. This compares favourably with the typical efficiency of about 35 percent of a conventional power station.

The STMicroelectronics wafer plant in Singapore has a corporate goal to reduce total energy consumed by at least 5 percent per

year. By having a very good environmental management system in place, the company managed to achieve an energy saving of 14 percent per wafer produced per year for the period 1991-96, significantly outperforming its corporate target.

The Shangri-La Hotel in Singapore has recently upgraded its air-conditioning plants. It had operated an air-conditioning system of 3,252 refrigeration tonnes (RT) capacity at an average efficiency of 1.22 kW per RT. It has since upgraded the air-conditioning system with better equipment. The current installed capacity is 2,600 RT with an average system efficiency of 0.68 kW per RT. The project has resulted in a saving of 14,400 kWh of electricity per day.

Building Sector

For the building sector, much has been done to achieve energy efficiency. The policy focus is to get it right at the design stage by imposing regulatory requirements. Since 1979, energy conservation standards for the design of buildings have been incorporated in the building code. The energy conservation standards prescribe an Overall Thermal Transfer Value (OTTV) of not more than 45 W/m^2 to reduce heat transfer into a building.

The Income Tax Act complements the building regulations by allowing expenditure on OTTV improvement to be deducted as an expenditure instead of being treated as a capital expenditure that has to be depreciated over a period of time.

The Building Control Regulations include specific requirements on energy conservation such as zoning of air-conditioned space for temperature control and having an automatic control for each hotel guestroom to regulate lighting and air-conditioning when the room is not used.

The Building and Construction Authority (BCA) is in the process of reviewing and updating energy conservation standards for buildings to make future buildings more energy efficient. This is to take into account advances in technology for building materials that reduce heat gain into a building and technological advances in lighting equipment and accessories. This takes care of pre-construction requirements that have to be complied with at the building design stage before the approval of the building plan.

The BCA is also embarking on a project to develop Energy Efficiency Indices (EEI) for commercial buildings. This is a post-construction building performance requirement. Eventually, building owners will be required to operate their buildings such that the energy consumption on a normalised basis (to take into account different operating hours, people density, etc.) will not exceed the EEI allowed for the buildings.

A total of 86 percent of Singapore's population is housed in

high-rise apartments built by the HDB. Electricity is consumed by domestic appliances and by the mechanical and electrical (M&E) installations in the common areas such as lifts and public lighting. The HDB spares no effort in adopting energy-saving measures in the design of public housing.

The apartments are designed for optimal natural ventilation to minimise the need for air-conditioning, a major energy consumer in the local hot and humid weather conditions of Singapore. Sun-shades are provided for apartments to reduce direct sunlight into the living areas. For M&E services, the following measures have been implemented:

- A variable-voltage, variable-frequency lift drive system has been adopted for lifts to save energy;
- Ventilation and lighting in lifts are arranged to be automatically switched off when the lifts are not in use;
- Low loss ballasts and energy-saving fluorescent tubes are used for public lighting in multi-storey carparks;
- Energy-saving lamps such as compact PL lamps, high-pressure sodium lamps and metal halide lamps are used for public lighting and in parks, playgrounds and landscaped areas;
- Public lighting is wired using dual circuiting so that some lamps can be switched off at a certain pre-set time (e.g., after mid-night) when less light is needed; and
- Public lighting is switched on and off using photocells to optimise the use of natural daylight.

The HDB continuously looks into improvements in the design of housing units in its estates. To achieve energy efficiency, the HDB has adopted several principles in urban design, housing and the

Public housing designed for optimal natural ventilation.

general built form. These principles are best illustrated by the following measures the HDB has adopted in its latest new town, Punggol 21:

- Structure Development Around Energy-Efficient Movement Network

  To reduce the level of reliance on cars and the need to travel, the planners focus on the circulation of people on foot and the effectiveness of public transportation, thereby improving energy efficiency for transportation. Public transportation facilities like the Mass Rapid Transit (MRT) and Light Rail Transit (LRT) are well integrated with housing developments and community facilities to ensure good accessibility to public transport. The provision of community facilities near housing developments reduces the need to travel.
- Open Space Network and Pedestrian Permeability and Accessibility

  The new town is divided into smaller estates of 1,200 to 2,800 dwelling units served by a park. The parks are linked together in an open space network so that walking is the natural and pleasurable means of access between activities and becomes a social activity in itself, thereby reducing the reliance on transport facilities.
- An Energy Strategy that Reduces Heat Gain

  Every new residential development employs an energy strategy that includes reducing heat gain through several measures. These measures include siting buildings to avoid window openings from facing the setting sun, cooling internal spaces by encouraging cross ventilation, and reducing heat gain through reflection from surrounding structures. Where there is a need, shading devices are used to reduce heat gain and to help cooling. Landscaping is used creatively to provide a more sheltered micro-climate for buildings and external spaces.

Transportation

Three basic tenets of our land transport policy contribute to energy efficiency and reduction in carbon dioxide from vehicles. These are:

- minimising the need to travel through integrated land use and transportation planning;
- promoting a viable and efficient public transport system that integrates the MRT, LRT and bus services; and
- managing the growth and use of private vehicles.

The benefit in promoting public transportation is obvious from a comparison of the relative energy use by various modes of transport. It is estimated that if a train uses one unit of energy to transport a person for a certain distance, a bus would use 2.5 units and a

An efficient mass rapid transportation system offers a viable alternative to private cars.

car carrying only the driver would use 11 units to accomplish the same purpose. Singapore already has a very good public transport system. As at December 1999, there are 3,000 buses and 83 kilometres of MRT lines. Together, they achieve 3 million trips per day. A new LRT system was opened in November 1999. There are plans to build more MRT and LRT systems. By 2005, another 65 kilometres of MRT/LRT lines will have been built.

Over the years, the Land Transport Authority (LTA) has introduced many measures to limit vehicle ownership and discourage vehicle use. Car ownership in Singapore is regulated through very steep import duties, registration fees and a vehicle quota system. Annual road taxes are pegged to engine capacity, thereby penalising

The electronic road pricing system has helped to minimise road congestion.

the bigger capacity cars and encouraging the use of the more energy efficient smaller capacity cars. Petrol taxes are set high to discourage car use. The cost of vehicle ownership in Singapore is among the highest in the world. Singapore also operates the world's first electronic road pricing (ERP) system. All vehicles are fitted with an in-vehicle unit using a cashcard. The stored value in the cashcard is automatically deducted when a vehicle passes under overhead gantries which are erected at all entry points into the city and along the more congested expressways and major roads.

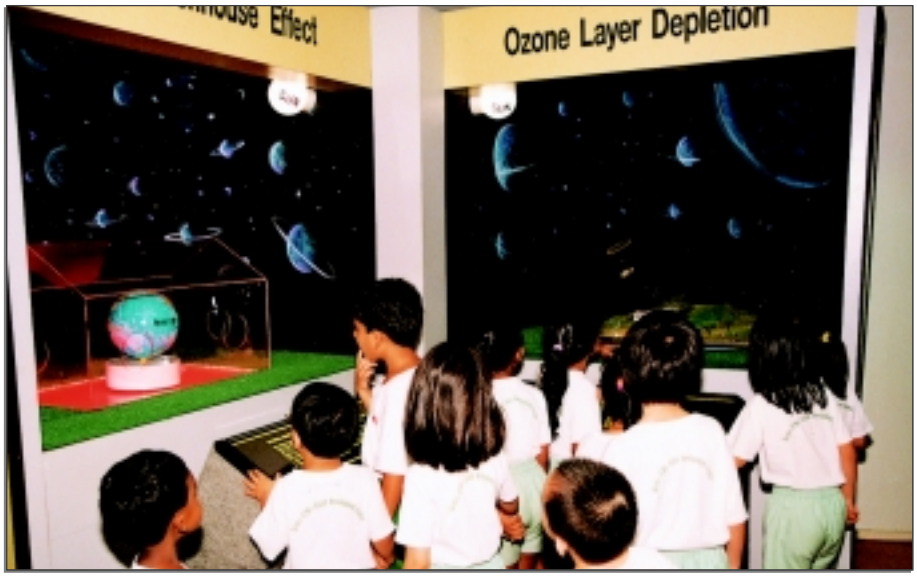
Over time this system will be extended. Although the primary objective of these measures is to prevent congestion, they also contribute to energy efficiency.

Some parameters on land transportation for 1998 are shown below:

Number of cars	:	375,217
Number of buses	:	11,162
Number of other vehicles	:	225,232
Length of paved roads	:	3,059 km
Route length of MRT	:	83 km

Public Awareness and Education Programme

The PUB has been conducting regular educational programmes and training courses on energy conservation since 1985. These programmes inculcate in school children the importance of energy conservation and teach them ways and means to use energy efficiently. With the restructuring of the PUB, the Electricity Efficiency Centre of Power Supply Ltd has taken over the programme. It promotes energy conservation among the general public through a wide range



Educating the young on the environment.

of films and video shows and makes publicity leaflets on energy conservation readily available to the general public. The centre also exhibits static and working displays on energy conservation. Singapore Power also provides residential households with yardsticks in their website (www.can.com.sg) that allow them to compare their electricity consumption against those of similar household units.

For the industrial and commercial sectors, the PUB provides energy consumption audit services and advice on energy conservation measures. The PUB also has an on-going programme that assists and encourages industries to set up energy auditing systems.

Many agencies are active in organising seminars and workshops on energy efficiency. Among them are the Institution of Engineers, Singapore Confederation of Industries, Singapore Hotel Association, PUB and Regional Institute of Environmental Technology. Their programmes are targeted at many sectors of the economy. The continuous education programmes create awareness and keep the relevant people updated on new developments in technology and energy management.

Energy-Efficient Appliances

The SEC, a non-government organisation, operates a voluntary Green Labelling Scheme. The product categories include appliances such as air-conditioners, domestic refrigerators, lights, washing machines and micro-computers. Energy consumption is one of the qualifying criteria. The SEC publicises the Green Labelling Scheme to encourage consumers to purchase GreenLabel products.

Tax Incentives

Several incentive schemes are available to encourage the adoption of energy-efficient technologies and installation of energy-efficient equipment. The Local Enterprise Technical Assistance Scheme (LETAS) can be used by local enterprises to engage external expertise to modernise and upgrade their operations, including making them more energy efficient. They can get financial grants of up to 70 percent of the cost of the consultancy subject to a maximum of S$40,000. They can also take advantage of an Investment Allowance Scheme that offers an exemption of taxable income of an amount equal to a specified proportion of the new investment.

There is also a tax incentive scheme under which companies can claim accelerated depreciation allowance in one year for the capital expenditure on energy-efficient equipment instead of the normal three years. The purpose of the scheme is to encourage companies to conserve energy by replacing older energy-inefficient air-conditioning systems, boilers, pumps and other equipment, and to invest in new energy-saving technologies such as heat-recovery systems and variable-speed drive motors.

Energy Recovery from Waste

The use of waste treatment technology to recover energy from waste has ameliorated the need to burn fossil fuels to generate electricity. As a matter of policy, all incinerable waste generated is incinerated and the heat is used to generate electricity. In 1999, the incineration plants burned 2.04 million tonnes of refuse and generated 830 million kWh of electricity.

All wastewater is collected for treatment at six sewage treatment works. Biogas produced during the anaerobic treatment process is used to generate electricity to meet in-house energy requirements at the treatment works. In 1999, 54.1 million kWh of electricity was generated from the wastewater treatment.

Renewable Energies

There are no hydro or geothermal energy sources that Singapore can harness. Singapore keeps a close watch on technological developments in other forms of renewable energy. It looks forward to the day when renewable energy can be tapped in countries with small land and sea areas, such as Singapore, on a large scale and in a commercially viable manner.

In the Singapore context, solar energy appears to have the best potential. One key challenge for a densely built-up city-state like Singapore is the development of the technological capability to harvest solar energy in a cost-effective manner and with minimum space utilisation. Hopefully, researchers will one day find creative ways to develop such a capability. In Singapore, research in this area is limited.

A number of institutions have embarked on some applied research into solar energy use. For example, researchers at the Singapore Polytechnic conducted some work to harness solar and wind energy. They built a wind turbine on a rooftop which, together with a solar farm system, could generate enough energy to light up the corridors of a five-storey building.

The Ministry of Defence (MINDEF) has installed a S$80,000 solar power system at its Tuas Naval Base in 1999 as a pilot study. The pilot project involves 56 photovoltaic panels lining the roof and part of the building façade. About one kW of electrical energy per hour is generated from 9 a.m. to 4 p.m. daily. MINDEF is looking into larger-scale applications using photovoltaic cells when a newer generation of thin-film photovoltaic cells is available commercially. MINDEF noted that the lighting of roads and perimeter fences of military facilities usually incur high costs involving running long lengths of cables and installing equipment to distribute electricity. It commenced a pilot trial that uses solar-powered lights at a military facility in mid-1999.

Harnessing renewable energy – solar energy collectors on the roof at Changi Airport. (Picture courtesy of Changi International Airport Services Pte. Ltd.)

Currently, solar heating is the only commercially viable application of solar energy. Solar heating has been used in some commercial facilities and private homes to produce hot water. A notable application is the S$400,000 solar heating system installed by the Changi International Airport at its Flight Kitchen Building. Installed in December 1996, the system provides more than 2,500 kWh of heat energy per day to meet the hot-water requirements for the preparation of food, cooking and washing. Similar systems are used by the Singapore Airport Terminal Services to provide hot water for staff bathing facilities and by the Changi International Airport for shower rooms at the Terminal 2 Transit Hotel and for washing purposes at restaurants.

Annex

Revised 1996 IPCC Methodology Worksheets

This spreadsheet contains sheet 1 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**
WORKSHEET	**1-1**
SHEETS	**1 OF 5**
COUNTRY	**SINGAPORE**
YEAR	**1994**

			STEP 1					
			A Production	B Imports	C Exports	D International Bunkers	E Stock Change	F Apparent Consumption
FUEL TYPES								**F=(A+B -C-D-E)**
Liquid Fossil	Primary Fuels	Crude Oil		51,240	60		367.541	50,812.25
		Orimulsion		0	0		0	0.00
		Natural Gas Liquids		0	0		0	0.00
	Secondary Fuels	Gasoline		2361.315	5938.537		107.002	-3,684.22
		Jet Kerosene		657.633	7215.71	1039	45.524	-7,642.60
		Other Kerosene		259.664	452.481		29.214	-222.03
		Shale Oil		0	0		0	0.00
		Gas / Diesel Oil		5164.643	17537.27		-54.799	-12,317.83
		Residual Fuel Oil		15255.97	24629.53	1039	211.354	-10,623.91
		LPG		3.922	546.899		4.571	-547.55
		Ethane		0	0		0	0.00
		Naphtha		1288.981	4376.703		72.328	-3,160.05
		Bitumen		4.183	861.098		-2.606	-854.31
		Lubricants		442.442	876.488		21.288	-455.33
		Petroleum Coke		14.786	2.306		0	12.48
		Refinery Feedstocks		0	0		28.674	-28.67
		Other Oil		32.605	265.811		293.401	-526.61
Liquid Fossil Totals								
Solid Fossil	Primary Fuels	Anthracite [a]	0	0.519	0.037			0.48
		Coking Coal	0	0	0			0.00
		Other Bit. Coal	0	0.274	1.22			-0.95
		Sub-bit. Coal	0	0.039	0.014			0.03
		Lignite	0	0.97	0.496			0.47
		Oil Shale	0	0	0			0.00
		Peat	0	0.325	4.614			-4.29
	Secondary Fuels	BKB & Patent Fuel		0	0			0.00
		Coke Oven/Gas Coke		41.421	32.615			8.81
Solid Fuel Totals								
Gaseous Fossil		Natural Gas (Dry)	0	0	0		0	0.00
Total								
Biomass total								
		Solid Biomass		0	0			0.00
		Liquid Biomass		0	0			0.00
		Gas Biomass		0	0			0.00

(a) If anthracite is not separately available, include with Other Bituminous Coal.

This spreadsheet contains sheet 2 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**
WORKSHEET	**1-1**
SHEETS	**2 OF 5**
COUNTRY	**SINGAPORE**
YEAR	**1994**

			STEP 2		STEP 3		
			G [b]	H	I	J	K
			Conversion Factor	Apparent Consumption	Carbon Emission Factor	Carbon Content	Carbon Content
FUEL TYPES			(TJ/Unit)	(TJ) H=(FxG)	(t C/TJ)	(t C) J=(HxI)	(Gg C) K=(J/1000)
Liquid Fossil	Primary Fuels	Crude Oil	42.71	2,170,191.33	20	43,403,826.51	43,403.83
		Orimulsion		0.00		0.00	0.00
		Natural Gas Liquids	43.12	0.00	17.2	0.00	0.00
	Secondary Fuels	Gasoline	44.8	-165,053.24	18.9	-3,119,506.15	-3,119.51
		Jet Kerosene	44.59	-340,783.58	19.5	-6,645,279.78	-6,645.28
		Other Kerosene	44.75	-9,935.89	19.6	-194,743.39	-194.74
		Shale Oil		0.00		0.00	0.00
		Gas / Diesel Oil	43.33	-533,731.40	20.2	-10,781,374.29	-10,781.37
		Residual Fuel Oil	40.19	-426,974.90	21.1	-9,009,170.45	-9,009.17
		LPG	47.31	-25,904.50	17.2	-445,557.33	-445.56
		Ethane		0.00		0.00	0.00
		Naphtha	45.01	-142,233.85	20	-2,844,677.01	-2,844.68
		Bitumen	40.19	-34,334.68	22	-755,362.93	-755.36
		Lubricants	40.19	-18,299.87	20	-365,997.47	-366.00
		Petroleum Coke	31	386.88	27.5	10,639.20	10.64
		Refinery Feedstocks	44.8	-1,284.60	20	-25,691.90	-25.69
		Other Oil	40.19	-21,164.34	20	-423,286.71	-423.29
Liquid Fossil Totals				450,877.37		8,803,818.31	8,803.82
Solid Fossil	Primary Fuels	Anthracite [a]		0.00		0.00	0.00
		Coking Coal		0.00		0.00	0.00
		Other Bit. Coal		0.00		0.00	0.00
		Sub-bit. Coal		0.00		0.00	0.00
		Lignite		0.00		0.00	0.00
		Oil Shale		0.00		0.00	0.00
		Peat		0.00		0.00	0.00
	Secondary Fuels	BKB & Patent Fuel		0.00		0.00	0.00
		Coke Oven/Gas Coke		0.00		0.00	0.00
Solid Fuel Totals				0.00		0.00	0.00
Gaseous Fossil		Natural Gas (Dry)	43.12	0.00	15.3	0.00	0.00
Total				450,877.37		8,803,818.31	8,803.82
Biomass total				0.00		0.00	0.00
		Solid Biomass		0.00		0.00	0.00
		Liquid Biomass		0.00		0.00	0.00
		Gas Biomass		0.00		0.00	0.00

(a) If anthracite is not separately available, include with Other Bituminous Coal.

(b) Please specify units.

This spreadsheet contains sheet 3 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**
WORKSHEET	**1-1**
SHEETS	**3 OF 5**
COUNTRY	**SINGAPORE**
YEAR	**1994**

			STEP 4		STEP 5		STEP 6
			L	M	N	O	P
			Carbon Stored	Net Carbon Emissions	Fraction of Carbon	Actual Carbon Emissions	Actual CO_2 Emissions
FUEL TYPES			**(Gg C)**	**(Gg C) M=(K-L)**	**Oxidised**	**(Gg C) O=(MxN)**	**(Gg CO_2) P=(Ox(44/12))**
Liquid Fossil	Primary Fuels	Crude Oil	0	43,403.83	0.99	42,969.79	157,555.89
		Orimulsion		0.00	0.99	0.00	0.00
		Natural Gas Liquids	0	0.00	0.99	0.00	0.00
	Secondary Fuels	Gasoline	0	-3,119.51	0.99	-3,088.31	-11,323.81
		Jet Kerosene	0	-6,645.28	0.99	-6,578.83	-24,122.37
		Other Kerosene	0	-194.74	0.99	-192.80	-706.92
		Shale Oil		0.00	0.99	0.00	0.00
		Gas / Diesel Oil	0.00	-10,781.37	0.99	-10,673.56	-39,136.39
		Residual Fuel Oil		-9,009.17	0.99	-8,919.08	-32,703.29
		LPG	84.15	-529.71	0.99	-524.41	-1,922.84
		Ethane	0.00	0.00	0.99	0.00	0.00
		Naphtha	851.16	-3,695.84	0.99	-3,658.88	-13,415.90
		Bitumen	159.46	-914.82	0.99	-905.67	-3,320.79
		Lubricants	29.74	-395.74	0.99	-391.78	-1,436.53
		Petroleum Coke	0	10.64	0.99	10.53	38.62
		Refinery Feedstocks	0	-25.69	0.99	-25.43	-93.26
		Other Oil	0	-423.29	0.99	-419.05	-1,536.53
Liquid Fossil Totals			1,124.51	7,679.31	0.99	7,602.51	27,875.89
Solid Fossil	Primary Fuels	Anthracite [a]		0.00		0.00	0.00
		Coking Coal	0.00	0.00		0.00	0.00
		Other Bit. Coal		0.00		0.00	0.00
		Sub-bit. Coal		0.00		0.00	0.00
		Lignite		0.00		0.00	0.00
		Oil Shale		0.00		0.00	0.00
		Peat		0.00		0.00	0.00
	Secondary Fuels	BKB & Patent Fuel		0.00		0.00	0.00
		Coke Oven/Gas Coke		0.00		0.00	0.00
Solid Fuel Totals			0.00	0.00		0.00	0.00
Gaseous Fossil		Natural Gas (Dry)	0.00	0.00	0.99	0.00	0.00
Total			**1,124.51**	**7,679.31**		**7,602.51**	**27,875.89**
Biomass total			0.00	0.00		0.00	0.00
		Solid Biomass		0.00		0.00	0.00
		Liquid Biomass		0.00		0.00	0.00
		Gas Biomass		0.00		0.00	0.00

(a) If anthracite is not separately available, include with Other Bituminous Coal.

This spreadsheet contains sheet 4 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**
WORKSHEET	**1-1**
SHEETS	**4 OF 5 EMISSIONS FROM INTERNATIONAL BUNKERS (INTERNATIONAL MARINE AND AIR TRANSPORT)**
COUNTRY	**SINGAPORE**
YEAR	**1994**

		STEP 1	STEP 2			STEP 3	
		A	B	C	D	E	F
		Quantities Delivered[a]	Conversion Factor (TJ/Unit)	Quantities Delivered (TJ)	Carbon Emission Factor (t C/TJ)	Carbon Content (t C)	Carbon Content (Gg C)
FUEL TYPES				C=(AxB)		E=(CxD)	F=(E/1000)
Solid Fossil	Other Bituminous Coal	0.00	0.00	0.00	0.00	0.00	0.00
	Sub-Bituminous Coal	0.00	0.00	0.00	0.00	0.00	0.00
Liquid Fossil	Gasoline	0.00	44.80	0.00	18.90	0.00	0.00
	Jet Kerosene	1,039.00	44.59	46,329.01	19.50	903,415.70	903.42
	Gas / Diesel Oil	0.00	43.33	0.00	20.20	0.00	0.00
	Residual Fuel Oil	1,039.00	40.19	41,757.41	21.10	881,081.35	881.08
	Lubricants	0.00	40.19	0.00	20.00	0.00	0.00
		Total	**88,086.42**				

(a) Quantities taken from column "International Bunkers" from Worksheet 1-1, Sheet 1 of 5.

This spreadsheet contains sheet 5 of Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**
WORKSHEET	**1-1**
SHEETS	**5 OF 5 EMISSIONS FROM INTERNATIONAL BUNKERS (INTERNATIONAL MARINE AND AIR TRANSPORT)**
COUNTRY	**SINGAPORE**
YEAR	**1994**

			STEP 4			STEP 5	STEP 6
		G	H	I	J	K	L
		Fraction of Carbon Stored	Carbon Stored (Gg C)	Net Carbon Emissions (Gg C)	Fraction of Carbon Oxidised	Actual Carbon Emissions (Gg C)	Actual CO_2 Emissions (Gg CO_2)
FUEL TYPES			H=(FxG)	I=(F-H)		K=(IxJ)	L=(Kx[44/12])
Solid Fossil	Other Bituminous Coal		0.00	0.00		0.00	0.00
	Sub-Bituminous Coal		0.00	0.00		0.00	0.00
Liquid Fossil	Gasoline		0.00	0.00		0.00	0.00
	Jet Kerosene	0	0.00	903.42	0.99	894.38	3,279.40
	Gas / Diesel Oil		0.00	0.00		0.00	0.00
	Residual Fuel Oil	0	0.00	881.08	0.99	872.27	3,198.33
	Lubricants	0.5	0.00	0.00		0.00	0.00
						Total[a]	**6,477.72**

(a) The bunkers emissions are not to be added to national totals.

This spreadsheet contains Auxiliary Worksheet 1-1, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM ENERGY**
WORKSHEET	**AUXILIARY WORKSHEET 1-1: ESTIMATING CARBON STORED IN PRODUCTS.**
SHEETS	**1 OF 1**
COUNTRY	**SINGAPORE**
YEAR	**1994**

	A	B	C	D	E	F	G	H
	Estimated Fuel Quantities	**Conversion Factor (TJ/Unit)**	**Estimated Fuel Quantities (TJ)**	**Carbon Emission Factor (t C/TJ)**	**Carbon Content (t C)**	**Carbon Content (Gg C)**	**Fraction of Carbon Stored**	**Carbon Stored (Gg C)**
FUEL TYPES			**C=(AxB)**		**E=(CxD)**	**F=(E/1000)**		**H=(FxG)**
Naphtha [a]	1181.91	45.01	53,197.77	20	1,063,955.40	1,063.96	0.8	851.16
Lubricants	74	40.19	2,974.06	20	59,481.20	59.48	0.5	29.74
Bitumen	180.343	40.19	7,247.99	22	159,455.67	159.46	1	159.46
Coal Oils and Tars (from Coking Coal)			0.00		0.00	0.00	0.75	0.00
Natural Gas [a]			0.00		0.00	0.00	0.33	0.00
Gas/Diesel Oil [a]			0.00		0.00	0.00	0.5	0.00
LPG [a]	129.265	47.31	6,115.53	17.2	105,187.07	105.19	0.8	84.15
Ethane [a]			0.00		0.00	0.00	0.8	0.00
Other Fuels [b]			0.00		0.00	0.00		0.00
			0.00		0.00	0.00		0.00
			0.00		0.00	0.00		0.00

(a) Enter these fuels when they are used as feedstocks.

(b) Use the Other Fuels rows to enter any other products in which carbon may be stored.

This spreadsheet contains sheet 1 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**1 OF 16 ENERGY INDUSTRIES**
COUNTRY	**SINGAPORE**
YEAR	**1994**

	STEP 1	STEP 2			STEP 3	
	A	B	C	D	E	F
ENERGY INDUSTRIES	**Consumption**	**Conversion Factor (TJ/Unit)**	**Consumption (TJ)**	**Carbon Emission Factor (t C/TJ)**	**Carbon Content (t C)**	**Carbon Content (Gg C)**
			C=(AxB)		**E=(CxD)**	**F=(E/1000)**
Crude Oil [a]			0.00		0.00	0.00
Natural Gas Liquids			0.00		0.00	0.00
Gasoline			0.00		0.00	0.00
Jet Kerosene			0.00		0.00	0.00
Other Kerosene			0.00		0.00	0.00
Gas/Diesel Oil	67.441	43.33	2,922.22	20.2	59,028.81	59.03
Residual Fuel Oil	3048.602	40.19	122,523.31	21.1	2,585,241.93	2,585.24
LPG			0.00		0.00	0.00
Ethane			0.00		0.00	0.00
Naphtha			0.00		0.00	0.00
Lubricants			0.00		0.00	0.00
Petroleum Coke			0.00		0.00	0.00
Refinery Gas	0	48.15	0.00	18.2	0.00	0.00
Anthracite			0.00		0.00	0.00
Coking Coal			0.00		0.00	0.00
Other Bituminous Coal			0.00		0.00	0.00
Sub-Bituminous Coal			0.00		0.00	0.00
Lignite			0.00		0.00	0.00
Peat			0.00		0.00	0.00
Patent Fuel			0.00		0.00	0.00
Brown Coal Briquettes			0.00		0.00	0.00
Coke Oven Coke			0.00		0.00	0.00
Gas Coke			0.00		0.00	0.00
Gas Works Gas			0.00		0.00	0.00
Coke Oven Gas			0.00		0.00	0.00
Blast Furnace Gas			0.00		0.00	0.00
Natural gas	1.4582752	41868	61,055.07	15.3	934,142.50	934.14
Municipal Solid Waste			0.00		0.00	0.00
Industrial Waste			0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
		Total	**186,500.60**			
Memo items:						
Wood/Wood Waste			0.00		0.00	0.00
Charcoal			0.00		0.00	0.00
Other Solid Biomass			0.00		0.00	0.00
Liquid Biomass			0.00		0.00	0.00
Gaseous Biomass			0.00		0.00	0.00
		Total Biomass	**0.00**			

(a) Include only consumption of crude that is burned, not crude oil which is refined into petroleum products.

This spreadsheet contains sheet 2 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**2 OF 16 ENERGY INDUSTRIES**
COUNTRY	**SINGAPORE**
YEAR	**1994**

			STEP 5			STEP 6
ENERGY INDUSTRIES	**G Fraction of Carbon Stored**	**H Carbon Stored (Gg C)**	**I Net Carbon Emissions (Gg C)**	**J Fraction of Carbon Oxidised**	**K Actual Carbon Emissions (Gg C)**	**L Actual CO_2 Emissions (Gg CO_2)**
		H=(FxG)	**I=(F-H)**		**K=(IxJ)**	**L=(Kx[44/12])**
Crude Oil [a]		0.00	0.00		0.00	0.00
Natural Gas Liquids		0.00	0.00		0.00	0.00
Gasoline		0.00	0.00		0.00	0.00
Jet Kerosene		0.00	0.00		0.00	0.00
Other Kerosene		0.00	0.00		0.00	0.00
Gas/Diesel Oil	0	0.00	59.03	0.99	58.44	214.27
Residual Fuel Oil	0	0.00	2,585.24	0.99	2,559.39	9,384.43
LPG		0.00	0.00		0.00	0.00
Ethane		0.00	0.00		0.00	0.00
Naphtha		0.00	0.00		0.00	0.00
Lubricants (b)		0.00	0.00		0.00	0.00
Petroleum Coke		0.00	0.00		0.00	0.00
Refinery Gas	0	0.00	0.00	0.99	0.00	0.00
Anthracite		0.00	0.00		0.00	0.00
Coking Coal		0.00	0.00		0.00	0.00
Other Bituminous Coal		0.00	0.00		0.00	0.00
Sub-Bituminous Coal		0.00	0.00		0.00	0.00
Lignite		0.00	0.00		0.00	0.00
Peat		0.00	0.00		0.00	0.00
Patent Fuel		0.00	0.00		0.00	0.00
Brown Coal Briquettes		0.00	0.00		0.00	0.00
Coke Oven Coke		0.00	0.00		0.00	0.00
Gas Coke		0.00	0.00		0.00	0.00
Gas Works Gas		0.00	0.00		0.00	0.00
Coke Oven Gas		0.00	0.00		0.00	0.00
Blast Furnace Gas		0.00	0.00		0.00	0.00
Natural gas	0	0.00	934.14	0.99	924.80	3,390.94
Municipal Solid Waste		0.00	0.00		0.00	0.00
Industrial Waste		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
					Total	**12,989.64**
Memo items:						
Wood/Wood Waste		0.00	0.00		0.00	0.00
Charcoal		0.00	0.00		0.00	0.00
Other Solid Biomass		0.00	0.00		0.00	0.00
Liquid Biomass		0.00	0.00		0.00	0.00
Gaseous Biomass		0.00	0.00		0.00	0.00
					Total Biomass	**0.00**

(a) Include only consumption of crude that is burned, not crude oil which is refined into petroleum products.

(b) Use a value of 0.5 for lubricants.

This spreadsheet contains sheet 3 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**3 OF 16 MANUFACTURING INDUSTRIES AND CONSTRUCTION**
COUNTRY	**SINGAPORE**
YEAR	**1994**

	STEP 1	STEP 2			STEP 3	
	A	B	C	D	E	F
MANUFACTURING INDUSTRIES AND CONSTRUCTION	**Consumption**	**Conversion Factor (TJ/Unit)**	**Consumption (TJ)**	**Carbon Emission Factor (t C/TJ)**	**Carbon Content (t C)**	**Carbon Content (Gg C)**
			C=(AxB)		**E=(CxD)**	**F=(E/1000)**
Crude Oil [a]			0.00		0.00	0.00
Natural Gas Liquids			0.00		0.00	0.00
Gasoline			0.00		0.00	0.00
Jet Kerosene			0.00		0.00	0.00
Other Kerosene			0.00		0.00	0.00
Gas/Diesel Oil	371.938	43.33	16,116.07	20.2	325,544.69	325.54
Residual Fuel Oil	1404.109	40.19	56,431.14	21.1	1,190,697.07	1,190.70
LPG			0.00		0.00	0.00
Ethane			0.00		0.00	0.00
Naphtha			0.00		0.00	0.00
Lubricants			0.00		0.00	0.00
Petroleum Coke			0.00		0.00	0.00
Refinery Gas	1074.597	48.15	51,741.85	18.2	941,701.59	941.70
Anthracite			0.00		0.00	0.00
Coking Coal			0.00		0.00	0.00
Other Bituminous Coal			0.00		0.00	0.00
Sub-Bituminous Coal			0.00		0.00	0.00
Lignite			0.00		0.00	0.00
Peat			0.00		0.00	0.00
Patent Fuel			0.00		0.00	0.00
Brown Coal Briquettes			0.00		0.00	0.00
Coke Oven Coke			0.00		0.00	0.00
Gas Coke			0.00		0.00	0.00
Gas Works Gas	0	0	0.00	0	0.00	0.00
Coke Oven Gas			0.00		0.00	0.00
Blast Furnace Gas			0.00		0.00	0.00
Natural gas			0.00		0.00	0.00
Municipal Solid Waste			0.00		0.00	0.00
Industrial Waste			0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
		Total	**124,289.06**			
Memo items:						
Wood/Wood Waste			0.00		0.00	0.00
Charcoal			0.00		0.00	0.00
Other Solid Biomass			0.00		0.00	0.00
Liquid Biomass			0.00		0.00	0.00
Gaseous Biomass			0.00		0.00	0.00
		Total Biomass	**0.00**			

Note: to separately identify emissions associated with autogeneration from those associated with process heat, copy sheets 3 and 4, clearly indicating the source of the emissions.

This spreadsheet contains sheet 4 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**4 OF 16 MANUFACTURING INDUSTRIES AND CONSTRUCTION**
COUNTRY	**SINGAPORE**
YEAR	**1994**

	STEP 4			STEP 5		STEP 6
	G	H	I	J	K	L
MANUFACTURING INDUSTRIES AND CONSTRUCTION	**Fraction of Carbon Stored[a]**	**Carbon Stored (Gg C)[a]**	**Net Carbon Emissions (Gg C)**	**Fraction of Carbon Oxidised**	**Actual Carbon Emissions (Gg C)**	**Actual CO_2 Emissions (Gg CO_2)**
		H=(FxG)	**I=(F-H)**		**K=(IxJ)**	**L=(Kx[44/12])**
Crude Oil [a]		0.00	0.00		0.00	0.00
Natural Gas Liquids		0.00	0.00		0.00	0.00
Gasoline		0.00	0.00		0.00	0.00
Jet Kerosene		0.00	0.00		0.00	0.00
Other Kerosene		0.00	0.00		0.00	0.00
Gas/Diesel Oil	0	0.00 (b)	325.54	0.99	322.29	1,181.73
Residual Fuel Oil	0	0.00	1,190.70	0.99	1,178.79	4,322.23
LPG	0	0.00 (b)	0.00		0.00	0.00
Ethane		0.00 (b)	0.00		0.00	0.00
Naphtha		0.00 (b)	0.00		0.00	0.00
Lubricants	(c)	0.00	0.00		0.00	0.00
Petroleum Coke		0.00	0.00		0.00	0.00
Refinery Gas	0	0.00	941.70	0.99	932.28	3,418.38
Anthracite		0.00	0.00		0.00	0.00
Coking Coal		0.00	0.00		0.00	0.00
Other Bituminous Coal		0.00	0.00		0.00	0.00
Sub-Bituminous Coal		0.00	0.00		0.00	0.00
Lignite		0.00	0.00		0.00	0.00
Peat		0.00	0.00		0.00	0.00
Patent Fuel		0.00	0.00		0.00	0.00
Brown Coal Briquettes		0.00	0.00		0.00	0.00
Coke Oven Coke		0.00	0.00		0.00	0.00
Gas Coke		0.00	0.00		0.00	0.00
Gas Works Gas	0	0.00	0.00	0	0.00	0.00
Coke Oven Gas		0.00	0.00		0.00	0.00
Blast Furnace Gas		0.00	0.00		0.00	0.00
Natural gas		0.00 (b)	0.00		0.00	0.00
Municipal Solid Waste		0.00	0.00		0.00	0.00
Industrial Waste		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
					Total	**8,922.33**
Memo items:						
Wood/Wood Waste		0.00	0.00		0.00	0.00
Charcoal		0.00	0.00		0.00	0.00
Other Solid Biomass		0.00	0.00		0.00	0.00
Liquid Biomass		0.00	0.00		0.00	0.00
Gaseous Biomass		0.00	0.00		0.00	0.00
					Total Biomass	**0.00**

(a) For naphtha, natural gas, gas/diesel oil, LPG and any other fuels used as feedstocks, do not fill out Column G. Complete Column H, using Auxiliary Worksheet 1-2.

(b) Use Auxiliary Worksheet 1-2 to fill out the cells for these products.

(c) Use a value of 0.5 for lubricants.

This spreadsheet contains sheet 5 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**5 OF 16 TRANSPORT**
COUNTRY	**SINGAPORE**
YEAR	**1994**

	STEP 1	STEP 2			STEP 3	
TRANSPORT	**A Consumption**	**B Conversion Factor (TJ/Unit)**	**C Consumption (TJ)**	**D Carbon Emission Factor (t C/TJ)**	**E Carbon Content (t C)**	**F Carbon Content (Gg C)**
			C=(AxB)		**E=(CxD)**	**F=(E/1000)**
Domestic Aviation [a]						
Gasoline	0		0.00		0.00	0.00
Jet Kerosene	0		0.00		0.00	0.00
			0.00		0.00	0.00
		Subtotal	**0.00**			
Road Transport						
Natural Gas			0.00		0.00	0.00
LPG			0.00		0.00	0.00
Gasoline	628.871	44.8	28,173.42	18.9	532,477.65	532.48
Gas/Diesel Oil	682.075	43.33	29,554.31	20.2	596,997.06	597.00
			0.00		0.00	0.00
		Subtotal	**57,727.73**			
Rail Transport						
Gas/Diesel Oil	0		0.00		0.00	0.00
Residual Fuel Oil	0		0.00		0.00	0.00
Anthracite	0		0.00		0.00	0.00
Other Bituminous Coal	0		0.00		0.00	0.00
Coke Oven Coke	0		0.00		0.00	0.00
			0.00		0.00	0.00
		Subtotal	**0.00**			
National Navigation [a]						
Gasoline			0.00		0.00	0.00
Gas/Diesel Oil			0.00		0.00	0.00
Residual Fuel Oil			0.00		0.00	0.00
Lubricants			0.00		0.00	0.00
Sub-Bituminous Coal			0.00		0.00	0.00
			0.00		0.00	0.00
		Subtotal	**0.00**			
Pipeline Transport						
Natural Gas	0		0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
		Subtotal	**0.00**			
		Total Transport [a]	**57,727.73**			
Memo items:						
Liquid Biomass			0.00		0.00	0.00
			0.00		0.00	0.00
		Total Biomass	**0.00**			

(a) Excluding international bunkers.

This spreadsheet contains sheet 6 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**6 OF 16 TRANSPORT**
COUNTRY	**SINGAPORE**
YEAR	**1994**

		STEP 4			STEP 5		STEP 6
TRANSPORT	**G Fraction of Carbon Stored**	**H Carbon Stored (Gg C)**		**I Net Carbon Emissions (Gg C)**	**J Fraction of Carbon Oxidised**	**K Actual Carbon Emissions (Gg C)**	**L Actual CO_2 Emissions (Gg CO_2)**
		H=(FxG)		**I=(F-H)**		**K=(IxJ)**	**L=(Kx[44/12])**
Domestic Aviation [a]							
Gasoline		0.00		0.00		0.00	0.00
Jet Kerosene		0.00		0.00		0.00	0.00
		0.00		0.00		0.00	0.00
						Subtotal	**0.00**
Road Transport							
Natural Gas		0.00		0.00		0.00	0.00
LPG		0.00		0.00		0.00	0.00
Gasoline	0	0.00		532.48	0.99	527.15	1,932.89
Gas/Diesel Oil	0	0.00		597.00	0.99	591.03	2,167.10
		0.00		0.00		0.00	0.00
						Subtotal	**4,099.99**
Rail Transport							
Gas/Diesel Oil		0.00		0.00		0.00	0.00
Residual Fuel Oil		0.00		0.00		0.00	0.00
Anthracite		0.00		0.00		0.00	0.00
Other Bituminous Coal		0.00		0.00		0.00	0.00
Coke Oven Coke		0.00		0.00		0.00	0.00
		0.00		0.00		0.00	0.00
						Subtotal	**0.00**
National Navigation [a]							
Gasoline		0.00		0.00		0.00	0.00
Gas/Diesel Oil		0.00		0.00		0.00	0.00
Residual Fuel Oil		0.00		0.00		0.00	0.00
Lubricants		0.00	(b)	0.00		0.00	0.00
Sub-Bituminous Coal		0.00		0.00		0.00	0.00
		0.00		0.00		0.00	0.00
						Subtotal	**0.00**
Pipeline Transport							
Natural Gas		0.00		0.00		0.00	0.00
		0.00		0.00		0.00	0.00
		0.00		0.00		0.00	0.00
						Subtotal	**0.00**
						Total Transport [a]	**4,099.99**
Memo items:							
Liquid Biomass		0.00		0.00		0.00	0.00
		0.00		0.00		0.00	0.00
						Total Biomass	**0.00**

(a) Excluding international bunkers.

(b) Use a value of 0.5 for lubricants.

This spreadsheet contains sheet 7 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**7 OF 16 MEMO ITEMS: INTERNATIONAL BUNKERS**
COUNTRY	**SINGAPORE**
YEAR	**1994**

MEMO ITEMS: INTERNATIONAL BUNKERS	**STEP 1 A Consumption**	**STEP 2 B Conversion Factor (TJ/Unit)**	**C Consumption (TJ)**	**STEP 3 D Carbon Emission Factor (t C/TJ)**	**E Carbon Content (t C)**	**F Carbon Content (Gg C)**
			C=(AxB)		**E=(CxD)**	**F=(E/1000)**
Intl. Marine Bunkers						
Gasoline	0		0.00		0.00	0.00
Gas/Diesel Oil			0.00		0.00	0.00
Residual Fuel Oil	1039	40.19	41,757.41	21.1	881,081.35	881.08
Lubricants			0.00		0.00	0.00
Sub-Bituminous Coal			0.00		0.00	0.00
			0.00		0.00	0.00
		Total	**41,757.41**			
Intl. Aviation Bunkers						
Gasoline			0.00		0.00	0.00
Jet Kerosene	1039	44.59	46,329.01	19.5	903,415.70	903.42
			0.00		0.00	0.00
		Total	**46,329.01**			

Note: Emissions of International Bunkers are excluded from national totals and are reported for informational purposes only.

This spreadsheet contains sheet 8 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**8 OF 16 MEMO ITEMS: INTERNATIONAL BUNKERS**
COUNTRY	**SINGAPORE**
YEAR	**1994**

		STEP 4			STEP 5	STEP 6
	G	H	I	J	K	L
MEMO ITEMS: INTERNATIONAL BUNKERS	**Fraction of Carbon Stored**	**Carbon Stored (Gg C)**	**Net Carbon Emissions (Gg C)**	**Fraction of Carbon Oxidised**	**Actual Carbon Emissions (Gg C)**	**Actual CO_2 Emissions (Gg CO_2)**
		H=(FxG)	**I=(F-H)**		**K=(IxJ)**	**L=(Kx[44/12])**
Intl. Marine Bunkers						
Gasoline		0.00	0.00		0.00	0.00
Gas/Diesel Oil		0.00	0.00		0.00	0.00
Residual Fuel Oil	0	0.00	881.08	0.99	872.27	3,198.33
Lubricants	(a)	0.00	0.00		0.00	0.00
Sub-Bituminous Coal		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
					Total	**3,198.33**
Intl. Aviation Bunkers						
Gasoline		0.00	0.00		0.00	0.00
Jet Kerosene	0	0.00	903.42	0.99	894.38	3,279.40
		0.00	0.00		0.00	0.00
					Total	**3,279.40**

(a) Use a value of 0.5 for lubricants.

Note: Emissions of International Bunkers are excluded from national totals and are reported for informational purposes only.

This spreadsheet contains sheet 9 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**9 OF 16 COMMERCIAL / INSTITUTIONAL SECTOR**
COUNTRY	**SINGAPORE**
YEAR	**1994**

	STEP 1	STEP 2			STEP 3	
	A	B	C	D	E	F
COMMERCIAL / INSTITUTIONAL SECTOR	**Consumption**	**Conversion Factor (TJ/Unit)**	**Consumption (TJ)**	**Carbon Emission Factor (t C/TJ)**	**Carbon Content (t C)**	**Carbon Content (Gg C)**
			C=(AxB)		**E=(CxD)**	**F=(E/1000)**
Gasoline			0.00		0.00	0.00
Jet Kerosene			0.00		0.00	0.00
Other Kerosene			0.00		0.00	0.00
Gas/Diesel Oil			0.00		0.00	0.00
Residual Fuel Oil			0.00		0.00	0.00
LPG	66.2998	47.31	3,136.64	17.2	53,950.27	53.95
Anthracite			0.00		0.00	0.00
Other Bituminous Coal			0.00		0.00	0.00
Lignite			0.00		0.00	0.00
Brown Coal Briquettes			0.00		0.00	0.00
Coke Oven Coke			0.00		0.00	0.00
Gas Works Gas	664.3	3.6	2,391.48	15.2	36,350.50	36.35
Coke Oven Gas			0.00		0.00	0.00
Natural gas			0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
		Total	**5,528.12**			
Memo items:						
Wood/Wood Waste			0.00		0.00	0.00
Charcoal			0.00		0.00	0.00
Other Solid Biomass			0.00		0.00	0.00
Liquid Biomass			0.00		0.00	0.00
Gaseous Biomass			0.00		0.00	0.00
		Total Biomass	**0.00**			

Note: to separately identify emissions associated with autogeneration from those associated with process heat, copy sheets 9 and 10, clearly indicating the source of the emissions.

This spreadsheet contains sheet 10 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**10 OF 16 COMMERCIAL / INSTITUTIONAL SECTOR**
COUNTRY	**SINGAPORE**
YEAR	**1994**

		STEP 4			STEP 5	STEP 6
	G	H	I	J	K	L
COMMERCIAL / INSTITUTIONAL SECTOR	**Fraction of Carbon Stored**	**Carbon Stored (Gg C)**	**Net Carbon Emissions (Gg C)**	**Fraction of Carbon Oxidised**	**Actual Carbon Emissions (Gg C)**	**Actual CO_2 Emissions (Gg CO_2)**
		H=(FxG)	**I=(F-H)**		**K=(IxJ)**	**L=(Kx[44/12])**
Gasoline		0.00	0.00		0.00	0.00
Jet Kerosene		0.00	0.00		0.00	0.00
Other Kerosene		0.00	0.00		0.00	0.00
Gas/Diesel Oil		0.00	0.00		0.00	0.00
Residual Fuel Oil		0.00	0.00		0.00	0.00
LPG		0.00	53.95	0.99	53.41	195.84
Anthracite		0.00	0.00		0.00	0.00
Other Bituminous Coal		0.00	0.00		0.00	0.00
Lignite		0.00	0.00		0.00	0.00
Brown Coal Briquettes		0.00	0.00		0.00	0.00
Coke Oven Coke		0.00	0.00		0.00	0.00
Gas Works Gas	0	0.00	36.35	0.99	35.99	131.95
Coke Oven Gas		0.00	0.00		0.00	0.00
Natural gas		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
					Total	**327.79**
Memo items:						
Wood/Wood Waste		0.00	0.00		0.00	0.00
Charcoal		0.00	0.00		0.00	0.00
Other Solid Biomass		0.00	0.00		0.00	0.00
Liquid Biomass		0.00	0.00		0.00	0.00
Gaseous Biomass		0.00	0.00		0.00	0.00
					Total Biomass	**0.00**

Note: to separately identify emissions associated with autogeneration from those associated with process heat, copy sheets 9 and 10, clearly indicating the source of the emissions.

This spreadsheet contains sheet 11 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**11 OF 16 RESIDENTIAL SECTOR**
COUNTRY	**SINGAPORE**
YEAR	**1994**

	STEP 1	STEP 2			STEP 3	
	A	B	C	D	E	F
RESIDENTIAL SECTOR	**Consumption**	**Conversion Factor (TJ/Unit)**	**Consumption (TJ)**	**Carbon Emission Factor (t C/TJ)**	**Carbon Content (t C)**	**Carbon Content (Gg C)**
			C=(AxB)		**E=(CxD)**	**F=(E/1000)**
Gasoline			0.00		0.00	0.00
Other Kerosene			0.00		0.00	0.00
Gas/Diesel Oil			0.00		0.00	0.00
Residual Fuel Oil			0.00		0.00	0.00
LPG	78.6731	47.31	3,722.02	17.2	64,018.82	64.02
Anthracite			0.00		0.00	0.00
Other Bituminous Coal			0.00		0.00	0.00
Sub-Bituminous Coal			0.00		0.00	0.00
Lignite			0.00		0.00	0.00
Peat			0.00		0.00	0.00
Patent Fuel			0.00		0.00	0.00
Brown Coal Briquettes			0.00		0.00	0.00
Coke Oven Coke			0.00		0.00	0.00
Gas Works Gas	381.5	3.6	1,373.40	15.2	20,875.68	20.88
Coke Oven Gas			0.00		0.00	0.00
Natural gas			0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
		Total	**5,095.42**			
Memo items:						
Wood/Wood Waste			0.00		0.00	0.00
Charcoal			0.00		0.00	0.00
Other Solid Biomass			0.00		0.00	0.00
Liquid Biomass			0.00		0.00	0.00
Gaseous Biomass			0.00		0.00	0.00
		Total Biomass	**0.00**			

This spreadsheet contains sheet 12 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**12 OF 16 RESIDENTIAL SECTOR**
COUNTRY	**SINGAPORE**
YEAR	**1994**

	STEP 4			STEP 5		STEP 6
RESIDENTIAL SECTOR	**G Fraction of Carbon Stored**	**H Carbon Stored (Gg C)**	**I Net Carbon Emissions (Gg C)**	**J Fraction of Carbon Oxidised**	**K Actual Carbon Emissions (Gg C)**	**L Actual CO_2 Emissions (Gg CO_2)**
		H=(FxG)	**I=(F-H)**		**K=(IxJ)**	**L=(Kx[44/12])**
Gasoline		0.00	0.00		0.00	0.00
Other Kerosene		0.00	0.00		0.00	0.00
Gas/Diesel Oil		0.00	0.00		0.00	0.00
Residual Fuel Oil		0.00	0.00		0.00	0.00
LPG		0.00	64.02	0.99	63.38	232.39
Anthracite		0.00	0.00		0.00	0.00
Other Bituminous Coal		0.00	0.00		0.00	0.00
Sub-Bituminous Coal		0.00	0.00		0.00	0.00
Lignite		0.00	0.00		0.00	0.00
Peat		0.00	0.00		0.00	0.00
Patent Fuel		0.00	0.00		0.00	0.00
Brown Coal Briquettes		0.00	0.00		0.00	0.00
Coke Oven Coke		0.00	0.00		0.00	0.00
Gas Works Gas	0	0.00	20.88	0.99	20.67	75.78
Coke Oven Gas		0.00	0.00		0.00	0.00
Natural gas		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
					Total	**308.17**
Memo items:						
Wood/Wood Waste		0.00	0.00		0.00	0.00
Charcoal		0.00	0.00		0.00	0.00
Other Solid Biomass		0.00	0.00		0.00	0.00
Liquid Biomass		0.00	0.00		0.00	0.00
Gaseous Biomass		0.00	0.00		0.00	0.00
					Total Biomass	**0.00**

This spreadsheet contains sheets 13 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**13 OF 16 AGRICULTURE / FORESTRY / FISHING**
COUNTRY	**SINGAPORE**
YEAR	**1994**

	STEP 1	STEP 2			STEP 3	
	A	B	C	D	E	F
AGRICULTURE / FORESTRY / FISHING	**Consumption**	**Conversion Factor (TJ/Unit)**	**Consumption (TJ)**	**Carbon Emission Factor (t C/TJ)**	**Carbon Content (t C)**	**Carbon Content (Gg C)**
			C=(AxB)		**E=(CxD)**	**F=(E/1000)**
Mobile						
Gasoline			0.00		0.00	0.00
Jet Kerosene			0.00		0.00	0.00
Other Kerosene			0.00		0.00	0.00
Gas/Diesel Oil			0.00		0.00	0.00
Residual Fuel Oil			0.00		0.00	0.00
LPG			0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
		Total Mobile	**0.00**			
Stationary						
Gasoline			0.00		0.00	0.00
Other Kerosene			0.00		0.00	0.00
Gas/Diesel Oil			0.00		0.00	0.00
Residual Fuel Oil			0.00		0.00	0.00
LPG			0.00		0.00	0.00
Anthracite			0.00		0.00	0.00
Coking Coal			0.00		0.00	0.00
Other Bituminous Coal			0.00		0.00	0.00
Lignite			0.00		0.00	0.00
Patent Fuel			0.00		0.00	0.00
Brown Coal Briquettes			0.00		0.00	0.00
Coke Oven Coke			0.00		0.00	0.00
Gas Works Gas			0.00		0.00	0.00
Natural gas			0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
		Total Stationary	**0.00**			
Memo items:						
Mobile						
Liquid Biomass			0.00		0.00	0.00
Stationary						
Wood/Wood Waste			0.00		0.00	0.00
Charcoal			0.00		0.00	0.00
Other Solid Biomass			0.00		0.00	0.00
Liquid Biomass			0.00		0.00	0.00
Gaseous Biomass			0.00		0.00	0.00
		Total Biomass	**0.00**			

Note: to separately identify emissions associated with autogeneration from those associated with process heat, copy sheets 13 and 14, clearly indicating the source of the emissions.

This spreadsheet contains sheets 14 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**14 OF 16 AGRICULTURE / FORESTRY / FISHING**
COUNTRY	**SINGAPORE**
YEAR	**1994**

		STEP 4		STEP 5		STEP 6
	G	H	I	J	K	L
AGRICULTURE / FORESTRY / FISHING	**Fraction of Carbon Stored [a]**	**Carbon Stored (Gg C)**	**Net Carbon Emissions (Gg C)**	**Fraction of Carbon Oxidised**	**Actual Carbon Emissions (Gg C)**	**Actual CO_2 Emissions (Gg CO_2)**
		H=(FxG)	**I=(F-H)**		**K=(IxJ)**	**L=(Kx[44/12])**
Mobile						
Gasoline		0.00	0.00		0.00	0.00
Jet Kerosene		0.00	0.00		0.00	0.00
Other Kerosene		0.00	0.00		0.00	0.00
Gas/Diesel Oil		0.00	0.00		0.00	0.00
Residual Fuel Oil		0.00	0.00		0.00	0.00
LPG		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
					Total Mobile	**0.00**
Stationary						
Gasoline		0.00	0.00		0.00	0.00
Other Kerosene		0.00	0.00		0.00	0.00
Gas/Diesel Oil		0.00	0.00		0.00	0.00
Residual Fuel Oil		0.00	0.00		0.00	0.00
LPG		0.00	0.00		0.00	0.00
Anthracite		0.00	0.00		0.00	0.00
Coking Coal		0.00	0.00		0.00	0.00
Other Bituminous Coal		0.00	0.00		0.00	0.00
Lignite		0.00	0.00		0.00	0.00
Patent Fuel		0.00	0.00		0.00	0.00
Brown Coal Briquettes		0.00	0.00		0.00	0.00
Coke Oven Coke		0.00	0.00		0.00	0.00
Gas Works Gas		0.00	0.00		0.00	0.00
Natural gas		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
					Total Stationary	**0.00**
Memo items:						
Mobile						
Liquid Biomass		0.00	0.00		0.00	0.00
Stationary						
Wood/Wood Waste		0.00	0.00		0.00	0.00
Charcoal		0.00	0.00		0.00	0.00
Other Solid Biomass		0.00	0.00		0.00	0.00
Liquid Biomass		0.00	0.00		0.00	0.00
Gaseous Biomass		0.00	0.00		0.00	0.00
					Total Biomass	**0.00**

Note: to separately identify emissions associated with autogeneration from those associated with process heat, copy sheets 13 and 14, clearly indicating the source of the emissions.

(a) Use a value of 0.5 for lubricants.

This spreadsheet contains sheets 15 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**15 OF 16 OTHER (NOT ELSEWHERE SPECIFIED)**
COUNTRY	**SINGAPORE**
YEAR	**1994**

	STEP 1	STEP 2			STEP 3	
	A	B	C	D	E	F
OTHER (NOT ELSEWHERE SPECIFIED)	**Consumption**	**Conversion Factor (TJ/Unit)**	**Consumption (TJ)**	**Carbon Emission Factor (t C/TJ)**	**Carbon Content (t C)**	**Carbon Content (Gg C)**
			C=(AxB)		**E=(CxD)**	**F=(E/1000)**
Crude Oil	(a)		0.00		0.00	0.00
Natural Gas Liquids			0.00		0.00	0.00
Gasoline			0.00		0.00	0.00
Jet Kerosene			0.00		0.00	0.00
Other Kerosene			0.00		0.00	0.00
Gas/Diesel Oil			0.00		0.00	0.00
Residual Fuel Oil			0.00		0.00	0.00
LPG			0.00		0.00	0.00
Ethane			0.00		0.00	0.00
Naphtha			0.00		0.00	0.00
Lubricants			0.00		0.00	0.00
Petroleum Coke			0.00		0.00	0.00
Refinery Gas			0.00		0.00	0.00
Anthracite			0.00		0.00	0.00
Coking Coal			0.00		0.00	0.00
Other Bituminous Coal			0.00		0.00	0.00
Sub-Bituminous Coal			0.00		0.00	0.00
Lignite			0.00		0.00	0.00
Peat			0.00		0.00	0.00
Patent Fuel			0.00		0.00	0.00
Brown Coal Briquettes			0.00		0.00	0.00
Coke Oven Coke			0.00		0.00	0.00
Gas Coke			0.00		0.00	0.00
Gas Works Gas			0.00		0.00	0.00
Coke Oven Gas			0.00		0.00	0.00
Blast Furnace Gas			0.00		0.00	0.00
Natural gas			0.00		0.00	0.00
Municipal Solid Waste			0.00		0.00	0.00
Industrial Waste			0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
			Total	**0.00**		
Memo items:						
Wood/Wood Waste			0.00		0.00	0.00
Charcoal			0.00		0.00	0.00
Other Solid Biomass			0.00		0.00	0.00
Liquid Biomass			0.00		0.00	0.00
Gaseous Biomass			0.00		0.00	0.00
		Total Biomass	**0.00**			

Note: to separately identify emissions associated with autogeneration from those associated with process heat, copy sheets 15 and 16,clearly indicating the source.

(a) Include only consumption of crude that is burned, not crude oil which is refined into petroleum products.

This spreadsheet contains sheets 16 of Worksheet 1-2, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)**
WORKSHEET	**1-2 STEP BY STEP CALCULATIONS**
SHEETS	**16 OF 16 OTHER (NOT ELSEWHERE SPECIFIED)**
COUNTRY	**SINGAPORE**
YEAR	**1994**

		STEP 4			STEP 5	STEP 6
	G	H	I	J	K	L
OTHER (NOT ELSEWHERE SPECIFIED)	**Fraction of Carbon Stored**	**Carbon Stored (Gg C)**	**Net Carbon Emissions (Gg C)**	**Fraction of Carbon Oxidised**	**Actual Carbon Emissions (Gg C)**	**Actual CO_2 Emissions (Gg CO_2)**
		H=(FxG)	**I=(F-H)**		**K=(IxJ)**	**L=(Kx[44/12])**
Crude Oil		0.00	0.00		0.00	0.00
Natural Gas Liquids		0.00	0.00		0.00	0.00
Gasoline		0.00	0.00		0.00	0.00
Jet Kerosene		0.00	0.00		0.00	0.00
Other Kerosene		0.00	0.00		0.00	0.00
Gas/Diesel Oil		0.00	0.00		0.00	0.00
Residual Fuel Oil		0.00	0.00		0.00	0.00
LPG		0.00	0.00		0.00	0.00
Ethane		0.00	0.00		0.00	0.00
Naphtha		0.00	0.00		0.00	0.00
Lubricants	(a)	0.00	0.00		0.00	0.00
Petroleum Coke		0.00	0.00		0.00	0.00
Refinery Gas		0.00	0.00		0.00	0.00
Anthracite		0.00	0.00		0.00	0.00
Coking Coal		0.00	0.00		0.00	0.00
Other Bituminous Coal		0.00	0.00		0.00	0.00
Sub-Bituminous Coal		0.00	0.00		0.00	0.00
Lignite		0.00	0.00		0.00	0.00
Peat		0.00	0.00		0.00	0.00
Patent Fuel		0.00	0.00		0.00	0.00
Brown Coal Briquettes		0.00	0.00		0.00	0.00
Coke Oven Coke		0.00	0.00		0.00	0.00
Gas Coke		0.00	0.00		0.00	0.00
Gas Works Gas		0.00	0.00		0.00	0.00
Coke Oven Gas		0.00	0.00		0.00	0.00
Blast Furnace Gas		0.00	0.00		0.00	0.00
Natural gas		0.00	0.00		0.00	0.00
Municipal Solid Waste		0.00	0.00		0.00	0.00
Industrial Waste		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
					Total	**0.00**
Memo items:						
Wood/Wood Waste		0.00	0.00		0.00	0.00
Charcoal		0.00	0.00		0.00	0.00
Other Solid Biomass		0.00	0.00		0.00	0.00
Liquid Biomass		0.00	0.00		0.00	0.00
Gaseous Biomass		0.00	0.00		0.00	0.00
					Total Biomass	**0.00**

Note: to separately identify emissions associated with autogeneration from those associated with process heat, copy sheets 15 and 16,clearly indicating the source.(a) Use a value of 0.5 for lubricants.

This spreadsheet contains Worksheet 6-4, in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

MODULE	**WASTE**				
SUBMODULE	**INDIRECT NITROUS OXIDE EMISSIONS FROM HUMAN SEWAGE**				
WORKSHEET	**6-4**				
SHEET	**1 OF 1**				
COUNTRY	**SINGAPORE**				
YEAR	**1994**				
	A **Per Capita Protein Consumption (Protein in kg/person/yr)**	**B** **Population (number)**	**C** **Fraction of Nitrogen in Protein Frac$_{NPR}$ (kg N/kg protein)**	**D** **Emission factor EF$_6$ (kg N_2O-N/kg sewage-N produced)**	**E** **Total Annual N_2O Emissions (Gg N_2O/yr)**
					E = (A x B x C x D) x (44/28) / 1 000 000
Total	21.9	3363500	0.16	0.01	0.19