SINGAPORE'S SECOND **NATIONAL COMMUNICATION**

Under the United Nations Framework Convention on Climate Change

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November 2010

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PUBLISHED BY

National Environment Agency
Environment Building
40 Scotts Road
Singapore 228231

IN COLLABORATION WITH

Ministry Of The Environment And Water Resources
Ministry Of Foreign Affairs
Ministry Of National Development
Ministry Of Transport
Ministry Of Trade And Industry
National Climate Change Secretariat

ISBN: 9971-88-779-7

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FOREWORD

The serious and urgent global issue of climate change calls for concerted international action. All countries have to play their part based on their common but differentiated responsibilities, their respective capabilities, and their national circumstances.

Singapore chaired the Preparatory Committee and the Main Committee of the United Nations Conference on Environment And Development (UNCED) from 1990 to 1992. Singapore is also among the 154 countries that have ratified the United Nations Framework Convention on Climate Change (UNFCCC). We associated ourselves with the Copenhagen Accord as the basis for further negotiations. We supported the efforts by the Chairs of the Ad-Hoc Working Group on Long-term Cooperative Action (AWGLCA) and the Ad-Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWGKP) to move the process forward.

As a non-Annex I Party to the UNFCCC, we are not subject to binding greenhouse gas emission reduction commitments under the Kyoto Protocol. Our contribution to global greenhouse gas emissions is, and will remain, small. Nonetheless, as a small-island state vulnerable to the impacts of global climate change, Singapore takes climate change seriously. We will therefore continue to do our part in global efforts to address climate change.

As an alternative-energy disadvantaged economy with limited access to non-fossil fuel energy sources, our key strategy to mitigate greenhouse gas emissions is to improve energy efficiency in all sectors of the economy. An Energy Efficiency Programme Office was established in 2007 to drive national energy efficiency improvements. In 2009, the Government published the Sustainable Singapore Blueprint, which targets to improve our energy efficiency levels by 35% from 2005 levels by 2030.

In 2009, Singapore also pledged to undertake mitigation measures leading to a reduction of greenhouse gas emissions by 16% below 2020 Business-as-Usual (BAU) levels, contingent on a legally binding global agreement. Singapore will begin to implement the mitigation and energy efficiency measures announced under the Sustainable Singapore Blueprint target. Those measures are an integral part of the measures to achieve a 16% reduction below BAU.

They will build on significant steps we already undertook in the past to reduce emissions growth. Over the 20 year period from 1986 to 2007, green cover increased from 36% to 47% even though our population increased by 68% during this period. We are one of few countries to cap vehicle growth – we limited car growth to 3% and have lowered it further to 1.5% from 2009. Since 2001, we switched from fuel oil to natural gas, the cleanest form of fossil fuel, to generate electricity, almost 80% of which is now generated by natural gas. We recycle 56% and incinerate 41% of our waste, thus avoiding methane emissions from land fills.

Singapore will continue with these measures for greater energy and resource efficiency. They will be necessary to achieve sustainable development and to contribute to global efforts to address climate change.

Prof S Jayakumar

Senior Minister and
Chairman, Inter-Ministerial Committee on Climate Change
Republic of Singapore

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

COUNTRY CIRCUMSTANCES

Singapore's efforts to address climate change are constrained by the following circumstances:

i) Small, densely populated urban city-state

Singapore is a small island state, with a land area of approximately 707.18km^2. With a population of almost 4.8 million people, Singapore is the second most densely populated country in the world. Our small size and high population density magnify the potential consequences of global warming impacts such as a rise in sea level.

Singapore's small physical size also makes it difficult to compare our emissions, other than absolute emissions, with other countries which have larger populations and larger land areas. Even a comparison with comparable sized cities in larger countries will be invidious as there is no territory outside of the city limits of Singapore to which our industries can be moved.

ii) Energy-poor and alternative energy disadvantaged

Singapore's small land area, geographical location and other physical attributes make it energy-poor. We are dependent on fossil fuel imports for our energy needs and have limited access to alternative energy sources.

iii) Export-oriented economy

Singapore's export-oriented economy means that the bulk of Singapore's emissions are associated with the production of goods consumed by the world market. Deep cuts in emissions in the industrial sector should be undertaken in the context of an international agreement that addresses leakage.

SUSTAINABLE GROWTH

Singapore has grown its population and economy in a sustainable manner. Between 1990 and 2000, its population increased from 3.0 million to 4.0 million. In the same period, its economy grew from S$77 billion to S$160 billion (2000 prices). While pressures on its limited resources have increased, Singapore's energy intensity (per $GDP at 2000 prices) improved by 22% from 1990 to 2005. By 2007, Singapore's overall carbon intensity has fallen by 40% since 1990, and green cover has grown from 36% to 47%[1].

MANAGING CLIMATE CHANGE

National Greenhouse Gas Inventory

Singapore closely monitors and tracks its greenhouse gas emissions. Singapore accounts for less than 0.2% of global greenhouse gas emissions. Singapore's greenhouse gas emissions[2] for 2000

[1] Between 1986 and 2007
[2] Singapore's emission estimates were computed using the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

totalled 38,789.97Gg carbon dioxide (CO_2)-equivalent. CO_2 accounted for 97.3% of total emissions. Non-CO_2 gases such as methane, nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6) accounted for the remaining 2.7% of total emissions.

Vulnerability and Adaptation Measures

As some degree of climate change is already being felt, and global emissions will take time to stabilise and be reduced, Singapore will need to prepare for and adapt to the effects of climate change.

Singapore commissioned a vulnerability study to determine the likely long-term effects of climate change on Singapore, such as changes in rainfall patterns, sea levels, and extreme weather conditions. Phase 1 of the study was completed in 2009 and found that by 2100, both temperature and sea levels could rise at a rate comparable with global projections by the Intergovernmental Panel on Climate Change (IPCC). Phase 2 of the study, which looks into the projected impacts of climate change on building energy consumption, public health, and biodiversity, is currently on-going. The findings of the study will facilitate the identification of new adaptation measures as well as the review of existing adaptation measures.

Biodiversity is another area vulnerable to climate change impacts. To better measure urban efforts towards biodiversity conservation and sustainable development, Singapore led the development of a City Biodiversity Index (CBI) in partnership with the UN Convention on Biological Diversity (CBD) and the Global Partnership on Cities and Biodiversity. The CBI is acknowledged as one of the monitoring tools under the draft Plan of Action on Cities and Local Authorities for Biodiversity which will be presented for endorsement by the Conference of Parties to the CBD in October 2010.

Mitigation Measures

Singapore's key strategies to mitigate greenhouse gas emissions are to:

i) Adopt less carbon-intensive fuels

The predominant greenhouse gas emission in Singapore is CO_2 that arises from the combustion of fossil fuels. Singapore has switched from fuel oil to natural gas – the cleanest form of fossil fuel – for electricity generation since 2001. Currently, about 80% of Singapore's electricity is generated by natural gas.

ii) Increase energy efficiency

The Energy Efficiency Programme Office (E^2PO) was established to drive energy efficiency improvements in Singapore. The E^2PO developed a national energy efficiency plan, Energy Efficiency Singapore (E^2 Singapore), to drive energy efficiency efforts across the different sectors of our economy.

a) Households

Singapore's national campaign, the 10% Energy Challenge, raises the public's awareness of the benefits of energy efficiency and practical steps to reduce domestic electricity consumption by 10%. In addition, Mandatory Energy Labelling Scheme for major

appliances has been introduced so consumers can take into account energy efficiency in their purchase decisions. Minimum Energy Performance Standards for household refrigerators and air conditioners will be implemented by 2011, to remove the inefficient models from the market.

b) Industry

Singapore has various incentive schemes to encourage industry to adopt energy efficient practices and technologies, as well as build up capability in energy management. For example, the Singapore Certified Energy Manager Training Grant subsidises companies to send their facilities and operations management personnel for training in energy management; the Grant for Energy Efficient Technologies co-funds the cost of investing in energy efficient technologies and equipment in industrial facilities.

c) Buildings

The Building and Construction Authority's (BCA) Green Mark Scheme aims to encourage developers and owners to build and maintain greener buildings. BCA's Green Mark Scheme assesses building performance and environmental friendliness based on energy efficiency, water efficiency, project development and management, good indoor environmental quality and innovation. Legislation requires new buildings and existing buildings undergoing major retrofit to meet Green Mark criteria.

d) Transport

Singapore introduced the Mandatory Fuel Economy Labelling Scheme for new passenger cars and light goods vehicles to provide buyers with fuel economy information at the point of sale. A Green Vehicle Rebate Scheme is also in place to encourage adoption of green vehicles through tax rebates. These measures complement Singapore's existing congestion charging and vehicle population control measures which help ensure congestion-free traffic and a reduction in emissions.

iii) Invest in research and development

The Singapore Government is taking an active role in driving investment in research and development. Significant funding has been set aside for research into clean energy, focusing on research and manpower development. The Solar Energy Research Institute of Singapore (SERIS) was established in 2008 to encourage innovative solar energy research in Singapore, with a budget of about S$130 million over the first 5 years. Funding is also available for test-bedding new technologies. For example, Singapore's Housing Development Board (HDB) has embarked on a S$31 million island-wide test-bed of solar technology within 30 public housing precincts. Another S$25 million has been allocated to fund Clean Energy Scholarships, and programmes such as the Specialist Manpower Programme in Clean Energy and the Clean Energy Diploma programme have been established to prepare talent for a career in clean energy.

Framework for Coordination

As climate change cuts across the responsibilities of several Ministries, the **Inter-Ministerial Committee on Climate Change (IMCCC)** was formed in 2007 to formulate Singapore's international climate change strategy. It is chaired by Senior Minister S Jayakumar and comprises the Ministers from six ministries – Ministry of Foreign Affairs, Ministry of Trade and Industry,

Ministry of the Environment and Water Resources, Ministry of National Development, Ministry of Finance and Ministry of Transport.

An **Inter-Ministerial Committee on Sustainable Development (IMCSD)** was also set up in 2008 to set out Singapore's sustainable development strategy. It was co-chaired by the Ministers of the Ministry of the Environment and Water Resources, and Ministry of National Development. It comprised representation from five ministries – Ministry of Trade and Industry, Ministry of the Environment and Water Resources, Ministry of National Development, Ministry of Finance and Ministry of Transport.

The **Sustainable Singapore Blueprint (SSB)** was developed by the IMCSD following extensive private, people and public consultation. It was launched in April 2009 and details Singapore's key goals and initiatives on sustainable development for the next 20 years. The Blueprint goals will guide Singapore's development and ensure it grows sustainably in the decades ahead. To ensure that the Blueprint stays relevant, it will be reviewed every five years.

Sustainable Singapore Blueprint Goals by 2030

Energy	Reduce energy intensity (per S$ GDP) by 35% from 2005 levels.
Waste	Improve recycling rate from 56% in 2008 to 70%
Water	Reduce total domestic water consumption from 156 litres per capita per day in 2008 to 140 litres per capita per day
Air	Reduce the annual mean for ambient fine particulate matter (PM2.5) levels from 16µg/m^3 in 2008 to 12µg/m^3
	Cap SO_2 levels at 15µg/m^3
Physical Environment	Achieve a park provision of 0.8ha per 1,000 population
	Increase the length of park connectors from 100km in 2007 to 360km
	Introduce 50ha of skyrise greenery
	Increase reservoirs and waterways open for recreational use to 900ha of reservoirs and 100km respectively
Capability Building	Build Singapore into an environmental knowledge hub
Community Engagement	Nurture an environmentally responsible community

The initiatives undertaken to achieve these SSB goals are expected to contribute to a 7 to 11% reduction in emissions growth below 2020 Business-as-Usual (BAU) levels. They are an integral part of Singapore's voluntary commitment to a 16% reduction in emissions below 2020 BAU levels, contingent on a legally binding global agreement on climate change in which all countries implement their commitments in good faith, which was announced in 2009. This 16% target is a stretch target from the 7 to 11% reduction expected from the SSB. It demonstrates the Singapore Government's recognition of the need to further reduce our emissions growth, in conjunction with the efforts of other countries.

In March 2010, the government announced that IMCCC will focus both on formulating and implementing mitigation measures at home, and on international negotiation strategies. This will tighten coordination between international negotiations and Singapore's domestic policies, and ensure that Singapore delivers on its domestic commitments. The Committee is supported by the National Climate Change Secretariat, which has been strengthened, and is now headed by a Permanent Secretary under the Prime Minister's Office, to reflect the importance of policy matters to be coordinated.

Notes on using this document

As the National Communication is intended to be a retrospective of a country's performance, this document relies on data from 2000. However, to ensure its relevance and saliency to readers, this Second National Communication document also outlines Singapore's environmental initiatives at present till 2030.

CHAPTER ONE

NATIONAL CIRCUMSTANCES

CHAPTER ONE

NATIONAL CIRCUMSTANCES

COUNTRY IN BRIEF

Singapore is a small-island country in Southeast Asia and consists of one main island and some 60 small ones. It is located between latitudes 1° 09'N and 1° 29'N and longitudes 103° 36'E and 104° 25'E, approximately 137km north of the equator. It is separated from Peninsular Malaysia by the Straits of Johor and from the Indonesian islands by the Straits of Singapore.

LAND AREA

The main island of Singapore is about 47.2km from east to west and 23km from north to south with a coastline of 182.4km. The total land area (including that of the smaller islands) is about 707.18km^2. Among the islands, the larger ones are Pulau Tekong (24.4km^2), Pulau Ubin (10.2km^2) and Sentosa (3.5km^2).

Singapore's surface reaches 163m at its highest point. Much of the island lies within 15m of sea level. The country is generally flat.

CLIMATE

Singapore is an equatorial country with relatively uniform temperature, abundant rainfall, and high humidity. The average daily temperature is 26.9°C, with an average daily maximum of about 31°C and an average daily minimum of about 25°C. December and January are generally the coolest months.

Climatological Statistics

Mean daily temperature	26.9°C
Mean daily maximum temperature	31.1°C
Mean daily minimum temperature	24.8°C
Highest maximum temperature	36.0°C
Lowest minimum temperature	19.4°C
Mean daily relative humidity	84.2%
Mean daily maximum relative humidity	96.1%
Mean daily minimum relative humidity	64.3%
Extreme minimum relative humidity	33.0%
Mean annual rainfall	2,342.2mm
Highest annual rainfall	3,452.4mm
Lowest annual rainfall	1,118.9mm
Mean daily wind speed	2.5m/s

With an annual rainfall of 2,342mm, there is no distinct dry season, with rainfall throughout the year. The heaviest rainfall generally occurs from November to January. The driest months are usually in July and February. 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 from April to May and October to November.

February is usually the sunniest month while December is often the month with the least sunshine. February is also usually the windiest month of the year.

Relative humidity often exceeds 90% at night and in the early hours of the morning, shortly before sunrise. On dry afternoons, it is usually between 61 to 65%. The average daily relative humidity is 84.2%.

POPULATION

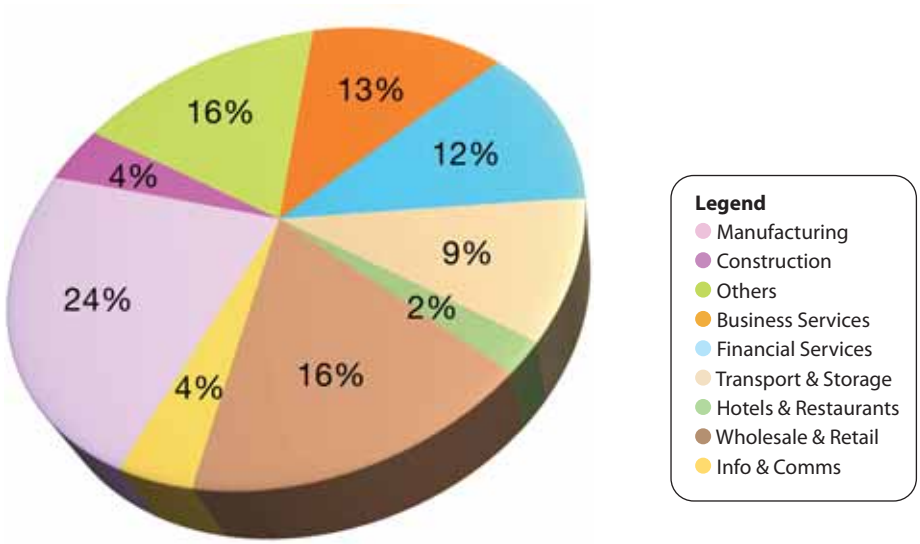
As of mid-2007, the resident population, comprising Singapore citizens and permanent residents, is estimated at 3.6 million, made up of 75.0% Chinese, 13.7% Malay, 8.7% Indian and a small percentage of other races[3]. The total population which includes foreigners holding work permits and employment passes working in Singapore is estimated at 4.8 million.

[3] Data on population and ethnic distribution are from Singapore Department of Statistics' 'Singapore in Figures 2008'.

ECONOMY

Singapore is an export-oriented economy that is highly dependent on international trade. In 2009, Singapore's external trade amounted to about S$750 billion, about three times the GDP of Singapore (S$258 billion). Over several decades, Singapore has built up a strong economy where manufacturing and financial and business services sectors comprised 24% and 25% of GDP in 2007 respectively. Singapore's small domestic market has necessitated an export-oriented economy, with the bulk of our industries manufacturing products for export rather than local consumption. For example, Singapore is one of the five largest export refining centres in the world, where our three refineries primarily produce for global export. Singapore's strategic geographical location has also enabled it to develop into a major air and sea transportation hub. The economic structure in 2007 is as shown.

Economic Structure in 2007



RESOURCE MANAGEMENT

LAND

Given Singapore's constraints, land is a scarce resource which requires careful management. Singapore therefore adopts a holistic approach towards land planning and development. The land-use planning and development control functions are overseen by a single agency, the Urban Redevelopment Authority (URA), which develops the Concept Plan and Master Plan for Singapore. This integrated approach ensures consistency, transparency and long-term sustainability with regards to land use.

The Concept Plan was first developed in 1971 and is reviewed in ten year intervals. It is Singapore's strategic land-use plan, which guides development over a few decades. It includes provisions for long-term land uses, such as housing, industry, commerce, recreation and open space, and supporting infrastructure, and balances Singapore's land needs within our constraints.

To translate these long-term plans into medium-term developmental initiatives, a detailed Master Plan is developed based on the Concept Plan's strategic directions. This Master Plan guides Singapore's development in the medium-term, over a period of 10 to 15 years and is reviewed every five years.

To ensure that various agencies' needs are catered for, both the Concept Plan and Master Plan are developed in a consultative and collaborative fashion. The comprehensive planning process is achieved through extensive coordination among government agencies, through an institutionalized process and various standing inter-agency committees. Comments and suggestions from the public are sought at different stages of the land use planning process. For example, 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.

ENERGY

A developing country, Singapore, with its small physical size and other attributes as well as its dependence on fossil fuels and its difficulties in switching to alternative sources of energy, is fully covered by the special considerations described in Articles 4.8 and 4.10 of the Convention.

Special Considerations under Articles 4.8 and 4.10 of the 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 response measures. Three sub-clauses in the article are of specific relevance to Singapore, namely:

4.8 (a)	Small island countries
4.8 (b)	Countries with low-lying coastal areas
4.8 (h)	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.

Article 4.10 of the UNFCCC states that the Parties shall take into consideration in the implementation of the commitments of the Convention the situation of Parties, particularly developing country Parties, with economies that are vulnerable to the adverse effects of the implementation of measures to respond to climate change. The article notes this applies especially to economies that are highly dependent on income generated from the production, processing and export, and/or consumption of fossil fuels and associated energy-intensive products and/or the use of fossil fuels for which such Parties have serious difficulties in switching to alternatives.

Given Singapore's limited land area, Singapore lacks the natural endowments necessary to make use of non-fossil energy alternatives to meet its needs. As such, Singapore is an "alternative energy-disadvantaged" country, as recognized under Articles 4.8 and 4.10 of the Convention.

Most alternative energy sources are not available in Singapore. Both hydroelectric power and tidal energy cannot be harnessed as Singapore lacks a major river system and has relatively calm seas. Singapore's limited land curtails the potential for sustainably grown domestic biomass as an alternative to fossil fuels. This lack of land, coupled with the low average wind speed of 2m/s, make the installation of wind turbines impractical. Singapore also does not have access to sources of geothermal energy.

While nuclear energy is a source of low-carbon electricity, it poses considerable challenges in safety and waste disposal and may thus not be a viable option. As Singapore is a small densely populated city-state, any nuclear incident would have a catastrophic effect.

Solar energy is thus far the only renewable energy source which offers some potential for Singapore. Even then, the restriction of physical size limits its use. Preliminary studies indicate that at current levels of technology, installing compact solar photovoltaic panels on all suitable rooftop space can only meet a small proportion of Singapore's total energy needs by 2020.

The Marina Barrage

Further research and development of solar technology will be required before small countries can exploit solar energy in a significant way. Singapore has therefore invested considerable resources into solar development, and has offered itself as a site for test-bedding solar technologies.

As a result, Singapore is for the foreseeable future – until there is significant technological breakthrough and advancements – dependent on fossil fuels for its energy needs.

WATER

Being in the equatorial rain belt, there is ample rain falling within Singapore. However, Singapore is water-scarce as it does not have sufficient land to collect and store the water, and has no other natural sources of water such as groundwater.

Ensuring water sustainability is crucial to Singapore. Today, Singapore has developed a diversified and robust supply of water through the Four National Taps, namely imported water, water collected from local catchments, NEWater and desalinated water.

Imported Water

Singapore has a long-term agreement with Malaysia for water. Singapore has been importing water from Johor, Malaysia, under the 1961 and 1962 Water Agreements. These agreements will expire in 2011 and 2061 respectively.

Local Catchment Water

Singapore is one of the few countries in the world to harvest urban stormwater on a large scale for its water supply. Rainwater is collected through a comprehensive network of drains, canals, rivers, stormwater collection tanks and reservoirs before it is treated for drinking water supply.

Singapore is expanding its catchment area[4] to maximise stormwater collection. Two-thirds of Singapore will be a water catchment area with the completion of the three new reservoir schemes at Marina, Punggol and Serangoon. The Marina Barrage, a 350m wide dam built across the mouth of the Singapore River, was completed in 2008. The sea water in the Marina Basin created by the Marina Barrage has been flushed out, creating Marina Reservoir – Singapore's fifteenth freshwater reservoir.

NEWater

NEWater is high-grade reclaimed water produced from treated used water that is further purified using advanced membrane technologies and ultraviolet disinfection, making it ultra-clean (higher than WHO standards) and safe to drink. By 2011, Singapore's fifth NEWater plant will be completed, and NEWater is expected to be able to meet 30% of the nation's water needs.

Desalination

Singapore has one of Asia's largest seawater reverse-osmosis plant, which produces 30 million gallons of desalinated water a day (136,000m^3).

[4] Water catchment areas in Singapore channel rainwater to Singapore's 17 reservoirs for storage.

With a projected increase in industrial activities and Singapore's population, water demand is expected to double in the long-term. To meet this growing need, Singapore has invested in technology to increase our water catchment to 90% of its land area. However, given the limits of Singapore's land area, there is still a need to concurrently increase alternative sources of water. In the longer term, NEWater and desalinated water should meet 50% and 30% of our future water needs respectively. These processes, which are highly energy intensive, are necessary for Singapore to be self sufficient in water.

FOOD

Given Singapore's small size, Singapore is not self-sufficient in meeting its food needs. As agriculture is land intensive, agricultural production is limited in Singapore, representing about 0.1% of GDP, or about S$187 million in 2007. Agricultural products include vegetables, eggs, fish, milk, orchids and other ornamental plants, and ornamental fish.

Singapore aims to develop its limited agricultural and fishery areas to produce quality food and to serve as benchmarks on food safety quality and pricing for imports and exports (i.e. export of ornamental fish and plants). As part of an overall food policy that seeks to ensure a stable and adequate supply of safe, wholesome and quality meat, fruits and vegetables in Singapore, agriculture policy seeks to develop sustainable urban agriculture with minimum impact on the environment. The Agri-food and Veterinary Authority (AVA) is the national authority safeguarding the health of people, animals, fish and plants through advanced technology in agriculture, fisheries and veterinary science.

A city of gardens and water

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 AVA, and cover a total of 2,000ha, with 1,500ha for Agrotechnology Park development and 500ha for Marine Park development. As of 2007, there were six Agrotechnology Parks, with 234 farms occupying some 716ha, producing vegetables, eggs, fish, milk, as well as ornamental plants and fish. A 10ha Agri-Bio Park dedicated to agri-biotechnology investments has also been established. The Parks have a mix of farms to minimise the spread of disease specific to a single type of species of plant or animal and to minimise environmental impact and pollution. Leafy vegetables are grown under protective netting and using the Integrated Pest Management (IPM) approach as well as Good Agricultural Practice.

In addition, there are ten Marine Parks with 99 floating fish farms in 2007, producing both finfish and shellfish. AVA regulates the number of farms in each Marine Park so as to prevent water stagnation and poor water quality within the farming site.

BIODIVERSITY

Today, about 10% of Singapore's total land area is dedicated to parks and Nature Reserves. Singapore has approximately 3,347ha of land area legally protected as Nature Reserves, which comprises key representative indigenous ecosystems. 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 forests are managed primarily for biodiversity conservation, water catchments, and the maintenance of our ecosystem services, as well as for recreational, educational, and research purposes. In addition to the four Nature Reserves, 18 Nature Areas have been identified in the 2008 Master Plan for their rich biodiversity and will be kept as long as possible. To encourage the greening of our urban environment and enhancement of our native biodiversity, there are on-going tree-planting and reforestation programmes, rehabilitation of native species in our parks and Nature Reserves, regulations requiring the conservation of mature trees, provision of planting strips and green buffers within developments, and incentives for skyrise greening. Various biological surveys have revealed that Singapore is a thriving habitat for 3,971 vascular plant species, 52 mammal species, 364 bird species, 98 reptile species, 28 amphibian species, 117 dragonfly species, and 255 hard coral species.

ENVIRONMENTAL PLANNING AND CONTROL

For more than 40 years, Singapore has based its environmental policies on the principle of advancing both economic development and environmental sustainability.

The success of the environmental protection measures is evident today in Singapore's clean and green environment. Singapore's ambient air compares well with that in other cities and is

in line with air quality standards set by the United States Environmental Protection Agency (USEPA), with the exception of fine particulate matter (PM2.5). With the implementation of Euro IV standards for new diesel vehicles from October 2006, air quality is targeted to meet the USEPA standard for PM2.5 by 2014. Key features of Singapore's environmental protection programme are the prevention of environmental degradation through careful land use planning and extensive infrastructural development. There is also close monitoring of air and water quality, with pre-emptive action taken quickly when risks of pollution are detected. Comprehensive pollution control laws are in place in Singapore, and these are enforced stringently.

PLANNING CONTROL

Pollution prevention starts at the planning stage. Industrial developments have to meet environmental regulations and are located in designated areas with buffer requirements to minimize their impact on residential areas. The impact of new industrial developments on the environment is carefully assessed before each development is allowed to proceed. This includes an assessment of its pollution impact to ensure that the prospective development will not pose any major health and safety hazards or pollution problems. A proposed development will be allowed only if the emission of pollutants complies with prescribed standards, wastes can be safely managed and properly disposed of, and the factory is sited in a suitable location.

Non-incinerable waste and ash from waste incineration are disposed offshore at the Semakau Landfill

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.

Sewerage System

Singapore has a comprehensive sewerage system which is developed to keep pace with new industrial, housing and commercial developments. All used water (waste water) is collected and treated at water reclamation plants (sewage treatment plants). Where feasible, treated effluent is reclaimed for further use as NEWater. Some S$2.5 billion have been invested in over 2,500km of sewers, 139 pumping stations and six water reclamation plants. The Ministry of the Environment and Water Resources (MEWR) also implemented Phase I of the Deep Tunnel Sewerage System (DTSS) – a network of deep tunnels comprising gravity sewers and pumping installations that intercepts used water flows in the existing sewerage reticulation system and channels. The used water flows to two new centralised water reclamation plants. The DTSS will enable Singapore to meet her used water needs through the 21st century.

Solid Waste Management System

All solid wastes in Singapore are collected and disposed of promptly to ensure high standards of environmental public health. With limited space for landfills, Singapore's policy with regard to all incinerable waste that is not recovered, reused, or recycled is to dispose of the waste at the 4 waste-to-energy incineration plants in Singapore. The incineration plants are fitted with flue gas cleaning devices and their emissions are monitored closely to ensure compliance with Singapore's air emission standards. The waste heat energy recovered from the incineration process is used to generate electricity, which satisfies about 2% of Singapore's total electricity demand. Scrap metals are also recovered and sold to a local steel mill for reprocessing into steel for the construction industry. In addition, MEWR has embarked on initiatives to encourage waste minimisation at source and recycling so as to minimise the amount of waste disposed of at the incineration plants and landfill.

Only 2% of all solid waste generated is landfilled at Singapore's only landfill on Semakau Island. The idea of an offshore landfill was conceived to accommodate the limited land space on mainland Singapore. This engineering feat became a reality in 1999, when Semakau Landfill was officially opened. It is the world's first man-made offshore landfill created entirely out of sea space and was created by enclosing 350ha of sea space between two islands, Pulau Sakeng and Pulau Semakau, with a 7km perimeter bund. Through the use of sophisticated technology such as geofabric to prevent waste contamination of the surrounding water, Semakau Landfill is clean and free of smell. The biodiversity in the mangrove swamps at Pulau Semakau has also been conserved, with a total of 400,000 mangrove saplings and a rich marine ecosystem. Since 2005, Semakau Landfill has been opened to members of interest groups for recreational activities such as inter-tidal walks, sport fishing and astronomy.

MONITORING AND ENFORCEMENT

Routine monitoring of the ambient air and inland and coastal waters as well as regular surveillance and inspection rounds are carried out to assess the adequacy and effectiveness of control programmes in maintaining a clean and healthy environment and to ensure that laws and regulations are complied with. Signs of deterioration are quickly identified and investigated. This allows action to be taken quickly before our air or water quality is adversely affected. Where pollution does occur, mitigation and enforcement action is promptly taken.

INSTITUTIONAL ARRANGEMENTS TO MANAGE CLIMATE CHANGE

Climate change is an issue with many dimensions that cut across the responsibilities of several ministries.

The Inter-Ministerial Committee on Climate Change (IMCCC) was therefore set up to ensure coordination on Singapore's position at international climate change negotiations. The IMCCC is chaired by the Senior Minister and Coordinating Minister for National Security, and includes the Minister for Foreign Affairs, the Minister for Trade and Industry, the Minister for the Environment and Water Resources, the Minister for Transport, the Minister for Finance and the Minister for National Development.

On the domestic front, the Inter-Ministerial Committee on Sustainable Development (IMCSD) was set up to articulate a clear national framework and strategy to achieve a high quality living environment that is sustainable and consistent with economic growth. The committee also sought to build new competencies and develop Singapore into a thought-centre for urban and environmental sustainability. The committee, jointly chaired by the Minister for National Development and the Minister for the Environment and Water Resources, included the Minister for Finance, the Minister for Transport and the Senior Minister of State for Trade & Industry.

In April 2009, the IMCSD released the Sustainable Singapore Blueprint[5]. Under the blueprint, the vision is for Singapore to develop by 2030 into a distinctive city that offers economic opportunity, vibrancy and a quality environment. Singapore will focus on four key priorities to achieve our vision:

i) Improve Resource Efficiency so that we can grow with fewer resources. If we can achieve more with less, we can reduce costs and free up precious resources to grow our economy. We will emerge more competitive in the long run.

ii) Improve the Quality of Our Environment by controlling pollution and improving our physical landscape, so that we can continue to enjoy clean air and water, and live in a well-connected city with high public health standards.

[5] The Blueprint is available at www.sustainablesingapore.gov.sg.

iii) Build Our Capabilities in how to grow in a more environmentally friendly way, using technology to overcome our resource constraints, now and in the future. As we experiment and build up our knowledge, Singapore can also work with others to promote and build sustainable cities around the world.

iv) Encourage Community Ownership and Participation in building a clean, green and resource-efficient Singapore. Business leaders, non-government organizations and community leaders can work together to encourage people to make more environmentally responsible choices in the way they live, work, play and commute.

Sustainable Singapore Blueprint Goals by 2030

Energy	Reduce energy intensity (per S$ GDP) by 35% from 2005 levels.
Waste	Improve recycling rate from 56% in 2008 to 70%
Water	Reduce total domestic water consumption from 156 litres per capita per day in 2008 to 140 litres per capita per day
Air	Reduce the annual mean for ambient fine particulate matter (PM2.5) levels from 16µg/m^3 in 2008 to 12µg/m^3
	Cap SO_2 levels at 15µg/m^3
Physical Environment	Achieve a park provision of 0.8ha per 1,000 population
	Increase the length of park connectors from 100km in 2007 to 360km
	Introduce 50ha of skyrise greenery
	Increase reservoirs and waterways open for recreational use to 900ha of reservoirs and 100km respectively
Capability Building	Build Singapore into an environmental knowledge hub
Community Engagement	Nurture an environmentally responsible community

In 2009, Singapore also pledged to undertake mitigation measures leading to a reduction of greenhouse gas emissions by 16% below 2020 Business-as-Usual (BAU) levels, contingent on a legally binding global agreement, in which all countries implement their commitments in good faith. The initiatives undertaken under the Sustainable Singapore Blueprint will contribute to and are an integral part of Singapore's voluntary commitment to a 16% reduction in emissions below 2020 BAU levels, conditional on a binding global agreement on climate change. This 16% target is a stretch target from the 7 to 11% reduction expected from the Sustainable Singapore Blueprint. It demonstrates the Singapore Government's recognition of the need to further reduce our emissions growth, in conjunction with the efforts of other countries.

CHAPTER TWO

NATIONAL GREENHOUSE GAS INVENTORY

CHAPTER TWO

NATIONAL GREENHOUSE GAS INVENTORY

The most significant greenhouse gas emitted in Singapore is carbon dioxide, primarily produced by the burning of fossil fuels to generate electricity used by the industry, building, household and transport sectors. The greenhouse gas emissions from agriculture, land-use change and forestry sectors are negligible. The small agricultural sector focuses mainly on produce such as eggs, fish and vegetables for local consumption to supplement our imports of these items. Some orchids and ornamental fish are also grown and reared for export. Land use change is insignificant as much of the country has been developed, except for the central forest area which is a protected water catchment.

METHODOLOGY USED

Singapore's emissions for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) were computed using the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories.

SINGAPORE'S EMISSIONS FOR THE YEAR 2000

Singapore's greenhouse gas emissions for 2000 totalled 38,789.97Gg CO_2-equivalent. CO_2 accounted for 97.3% of total emissions. Non-CO_2 gases such as CH_4, N_2O, PFCs, HFCs and SF_6 accounted for the remaining 2.7% of total emissions. A breakdown of our total greenhouse gas emissions by sources in CO_2-equivalent is shown in the table on page 23.

The estimated CH_4, N_2O, HFCs, PFCs, and SF_6 emissions were converted to CO_2-equivalent using 1995 IPCC global warming potential (GWP) values based on the effects of greenhouse gases over a 100-year time horizon in the table below.

Greenhouse Gas	Chemical Formula	GWP
Methane	CH_4	21
Nitrous oxide	N_2O	310
HFC-23	CHF_3	11,700
PFC-14	CF_4	6,500
PFC-116	C_2F_6	9,200
PFC-218	C_3F_8	7,000
PFC-c318	c-C_4F_8	8,700
Sulphur hexafluoride	SF_6	23,900

2000 National Greenhouse Gas Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of all Greenhouse Gases not Controlled by the Montreal Protocol

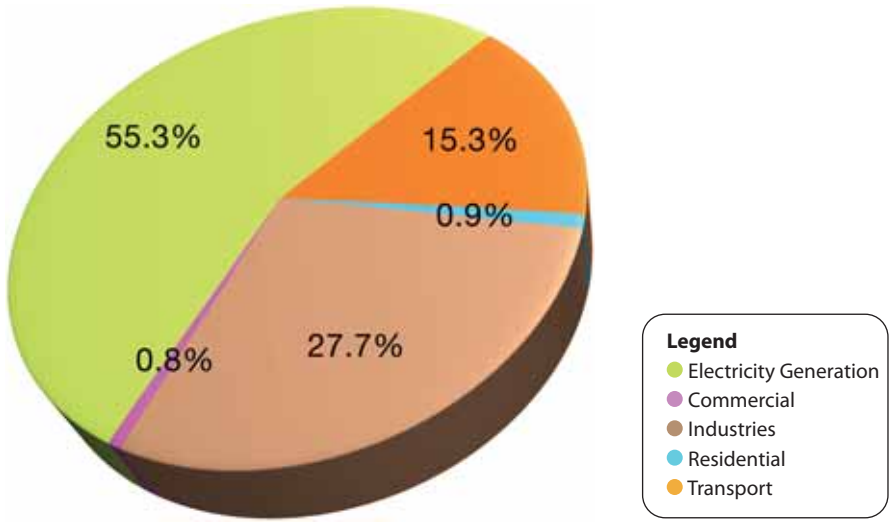
Greenhouse Gas Source and Sink Categories	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Total (Net) National Emissions (Gigagram CO_2-equivalent per year)	**37,755.81**	**111.72**	**334.87**	**7.47**	**496.06**	**84.04**
1. All Energy	**37,755.81**		**189.26**			
Fuel combustion						
Energy and transformation industries	20,973.74					
Industry	10,526.41					
Transport	5,621.57		189.26			
Commercial-institutional	291.63					
Residential	342.46					
Biomass burned for energy						
Fugitive fuel emission						
Oil and natural gas systems						
Coal mining						
2. Industrial Processes				**7.47**	**496.06**	**84.04**
3. Agriculture						
4. Land Use Change and Forestry						
5. Waste		**111.72**	**145.61**			
Solid waste disposal on land						
Wastewater handling		111.72	73.75			
Waste incineration			71.86			

a) All Energy

The combustion of fossil fuels in electricity generation is the major source of CO_2 emissions in Singapore. 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 figures refer to sectoral approaches unless otherwise specified. The amount of CO_2 emitted from the Energy sector in 2000 was a total of 37,755.81Gg. The contribution of CO_2 emissions from various sources under the Energy sector in 2000 is as shown.

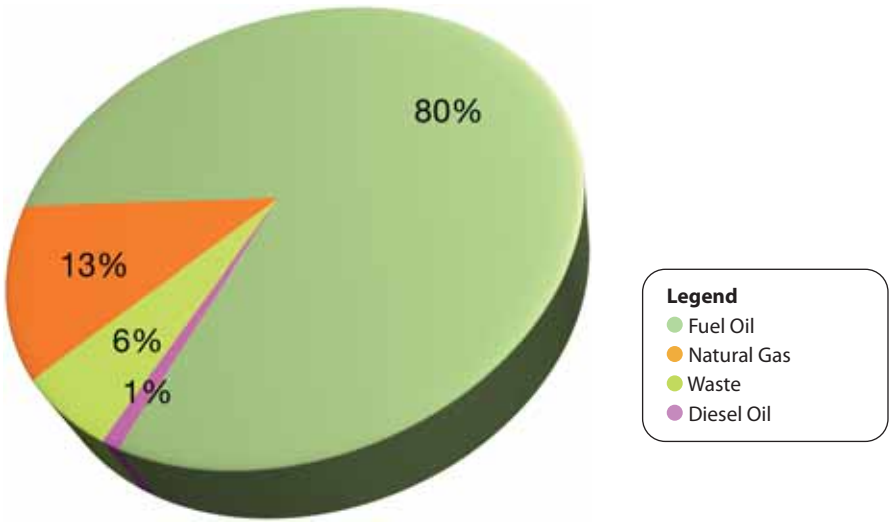
Breakdown of CO_2 Emission from the energy sector in 2000



ELECTRICITY GENERATION

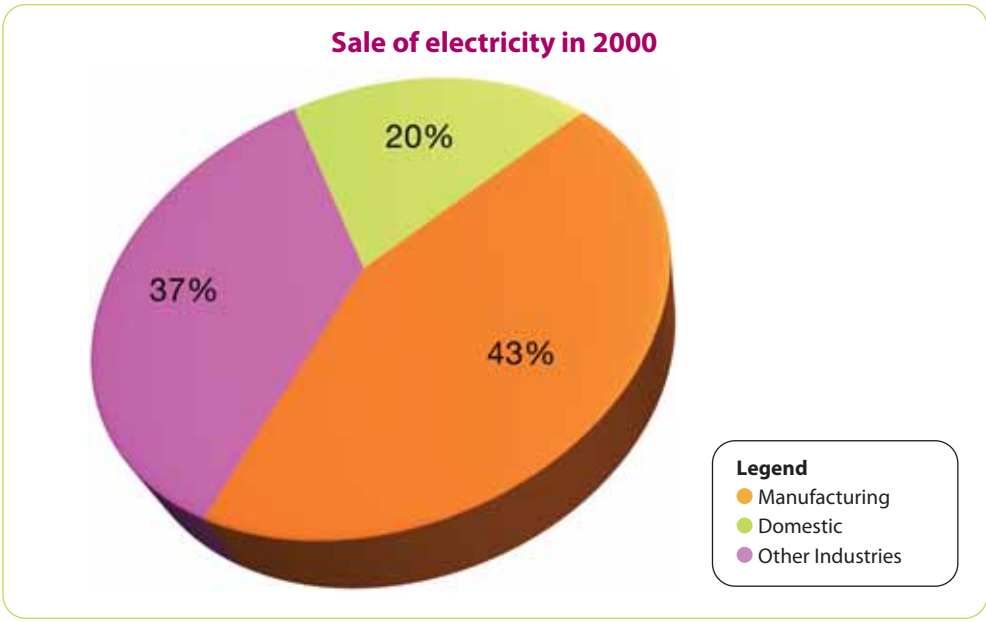
In 2000, the total amount of CO_2 emitted from electricity generation was 20,973.74Gg. The contribution of CO_2 emissions from different types of fuel used for electricity generation in 2000 is as shown.

Contribution of CO_2 Emissions from Different Types of Fuel Used for Electricity Generation in 2000



According to the IPCC Guidelines, CO_2 emissions from waste incineration are estimated from the portion of the waste that is fossil fuel based and exclude the biomass fraction. Waste incineration was estimated to contribute 1,300.50Gg of CO_2 to the total greenhouse gas emissions in 2000.

Sale of electricity amounted to 29,133.1 million kWh. The sale of electricity to the various sectors is as shown.



INDUSTRIES

Singapore does not produce any oil or gas. We are, however, a major oil refining and petrochemical centre that serves the global market. The oil refinery and petrochemical industries accounted for 9,283.81Gg of CO_2 emission and the other industries 1,242.60Gg.

TRANSPORT

In 2000, Singapore had a network of 3,100km of paved public roads and a population of 692,807 motor vehicles. These motor vehicles used diesel and petrol, utilising 1113.5 kilo-tonnes of diesel and 677.9 kilo-tonnes of petrol for the year 2000, which contributed 5,621.57Gg of CO_2 to total emissions. Land transport was estimated to contribute 0.61Gg of N_2O to the total greenhouse gas emissions in 2000. Based on a 100-year time horizon, where N_2O has a GWP of 310, the amount of N_2O emission is equivalent to 189.26Gg of CO_2.

COMMERCIAL AND RESIDENTIAL

Commercial and residential emissions were from the use of LPG and town gas[6] mainly for cooking and hot water systems. In 2000, 1,363.1 million kWh of town gas and 123 kilo-tonnes of LPG were consumed. This was equivalent to 634.09Gg of CO_2 emissions.

[6] Liquefied Petroleum Gas, or LPG, is a mixture of hydrocarbon gases formed as part of the petroleum refining process. Town Gas is primarily hydrogen gas generated through steam reforming of natural gas.

b) Industrial Processes

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

In the semiconductor industry, although HFCs, PFCs and SF_6 are used in the manufacturing process, emission control technologies were installed in some processes. The net emissions of these gases were estimated to be equivalent to 587.57Gg of CO_2- equivalent emissions.

c) Waste

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

i) Waste incineration;
ii) Managed solid waste disposal sites; and
iii) Wastewater handling.

For the year 2000, greenhouse gas emissions from the waste sector are summarised below.

Greenhouse Gas Source	Greenhouse Gas Emissions (Gg CO_2-equivalent)		
	CO_2	CH_4	N_2O
Waste incineration	-	-	71.86
Managed solid waste disposal sites	-	-	-
Wastewater handling	-	111.72	73.75

WASTE INCINERATION

As waste heat from the incineration process is used to produce electricity in Singapore, CO_2 emissions from waste incineration are reported in the Energy Sector. According to the IPCC Guidelines, CH_4 emissions from waste incineration are not likely to be significant because of the combustion conditions in incinerators. Waste incineration was estimated to contribute 71.86Gg of CO_2-equivalent in 2000.

MANAGED SOLID WASTE DISPOSAL SITES

Since the 1980s, all incinerable wastes in Singapore are disposed of at the incineration plants and only non-incinerables and ash from the incineration of wastes are disposed at the landfills. Therefore, emission of CH_4 from landfill sites is insignificant.

WASTEWATER HANDLING

Used water is conveyed, via sewers, to water reclamation plants for treatment. This includes, among other processes, an activated sludge process. The sludge is further stabilised in digesters. The biogas produced in the digesters is used as fuel to generate electricity to power the operation of the treatment facilities. Fugitive CH_4 emission from leakage and flaring activity is negligible.

From 1985 to 2008, treated sludge was used at three land reclamation sites: Changi East, Tuas View and Marina East. CH_4 emissions in 2000, due to anaerobic decay of the sludge contents from these sites, is estimated to be 111.72Gg of CO_2-equivalent.

Singapore's estimated N_2O emission from human sewage is 73.75Gg of CO_2-equivalent in 2000[7].

Parks and Nature Reserves

d) Carbon Sink

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

With careful land use planning, Singapore has been able to commit close to 10% of the total land area to parks and nature conservation. Despite a 70% increase in population over the past 20 years, our green cover has actually increased. Today, half of Singapore is covered by greenery. This is part of the government's programme to provide a pleasant living environment in a city state. These non-forest trees and shrubs constitute a sink for carbon sequestration. In addition, there are 2,500ha of forests that are safeguarded as Nature Reserves, and are conserved for ecological, educational, recreational and scientific purposes.

[7]Reports by the UN Food and Agriculture Organisation estimated Southeast Asia's protein intake to be 64g/capita/day. This is used as an estimate of Singapore's 2000 annual per capita protein intake as Singapore-specific figures are not available. 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 website: www.fao.org.

e) Uncertainty

Singapore's national inventory was assessed based on three levels of confidence as described in the 1996 Revised IPCC Guidelines. While there is general confidence in Singapore's data inventory reflected below, there is a low level of confidence for the N_2O data. This is because estimates were derived from proxy data[8].

Confidence Levels[9] of Data

Greenhouse Gas Source and Sink Category	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
1. All Energy						
Fuel combustion						
Reference Approach	M					
Sectoral Approach	M					
Energy and transformation industries	M					
Industry	M					
Transport	M		L			
Commercial-institutional	H					
Residential	H					
Biomass burned for energy						
Fugitive Fuel Emission						
Oil and natural gas systems						
Coal mining						
2. Industrial Processes				M	M	M
3. Agriculture						
4. Land Use Change and Forestry						
5. Waste						
Solid waste disposal on land						
Wastewater handling		M	L			
Waste incineration			L			

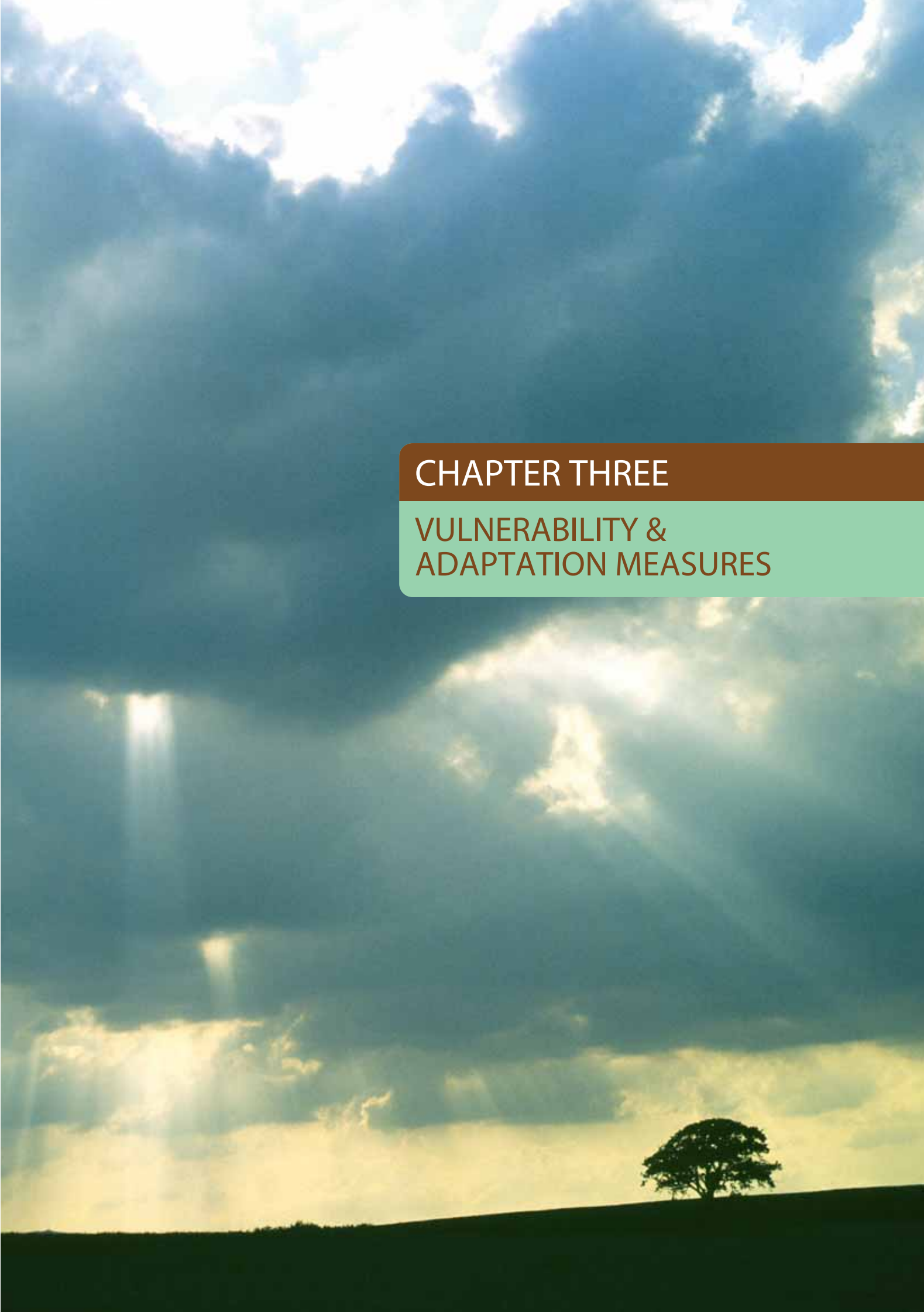
f) Sources of Data

The 2000 greenhouse gas emissions were estimated from information obtained from the following publications/ sources:

i) Singapore Year Book of Trade Statistics (Import and Export) 2001, International Enterprise Singapore;
ii) Monthly Digest of Statistics (March 2001), Department of Statistics;
iii) Land Transport Authority;
iv) Energy Market Authority;
v) Annual Report of the Public Utilities Board (2000);
vi) Annual Report of the Ministry of the Environment (2000); and
vii) Activity data submitted by companies.

[8]For example, FAO estimates of protein intake in Southeast Asia were used as we do not have Singapore-specific data, while the N_2O emissions were estimated from IPCC default values.

[9]Quality of greenhouse gas emissions emission estimates: H – High confidence in estimation; M – Medium confidence in estimation; L – Low confidence in estimation.



CHAPTER THREE

VULNERABILITY & ADAPTATION MEASURES

CHAPTER THREE

VULNERABILITY & ADAPTATION MEASURES

POSSIBLE CLIMATE CHANGE IMPACTS

According to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), global temperatures are projected to rise by 1.1-6.4°C by 2100 over 1990 levels, while global mean sea levels are expected to increase by 18-59cm over the same period, based on future scenarios of varying global emission levels. Temperature extremes, heat waves and heavy rainfall events are projected to become more frequent as well. For Southeast Asia, the IPCC AR4 projects a warming similar to global mean warming. Annual rainfall in Southeast Asia is also projected to increase by about 7%. Based on the projections of 21 models, the predicted annual rainfall changes for Southeast Asia range from -2% to +15% with a median change of +7%[10].

As a relatively low-lying, densely populated island in the tropics, Singapore is vulnerable to the impacts of climate change. Much of the island is less than 15m above sea level, with a generally flat coast. With a population of about 4.8 million, Singapore is one of the most densely populated countries in the world. In addition, Singapore has a relatively high uniform temperature and abundant rainfall, and is also situated in a region where vector-borne diseases such as dengue are endemic.

Given these circumstances, the possible impacts of climate change on Singapore include:

i) Flooding
ii) Coastal land loss
iii) Water resource impacts
iv) Public health impact from resurgence of diseases
v) Heat stress
vi) Impacts on island and marine biodiversity

As a result of environmental and developmental planning in the past, Singapore has measures in place that help address the potential climate change impacts.

At the same time, there is a need to continue monitoring the detailed effects and resulting impacts of climate change on Singapore. Singapore commissioned a study of the country's vulnerability to climate change in 2007. The study team was led by the Tropical Marine Science Institute of National University of Singapore (NUS), and comprised both local and foreign experts. A number of the foreign experts have been actively involved in the drafting and review of IPCC reports as well. The results of the study will facilitate the identification of new adaptation

[10] Based on the projections of 21 models, the predicted annual rainfall changes for Southeast Asia range from -2% to +15% with a median change of +7%.

measures as well as the review of existing adaptation measures. Phase 1 of the study was completed in 2009 and projected climate change effects such as temperature, sea level and rainfall patterns in Singapore in the next century.

The findings, which are summarised in the table below, are consistent with the projections in the 4th IPCC Assessment Report (AR4).

Climate Change Projections (in 2100 relative to present)	**IPCC AR4 Projections**	**Phase 1 Study Local Findings**
Change in Average Temperature(°C)	+ 1.7 to + 4.4 (A1B Scenario, SE Asia)	+ 2.7 to + 4.2 (A1B Scenario)
Change in Rainfall (%)	- 2% to + 15% (A1B Scenario, SE Asia)	No discernible trend. Further studies needed.
Change in Mean Sea Level (m)	+ 0.18 to + 0.59 (All IPCC Scenarios, Global)	+ 0.24 to + 0.65 (3 IPCC Scenarios)

Phase 2 of the study, which looks into the projected impacts of climate change on building energy consumption, public health, and biodiversity, is currently on-going. As climate change is an evolving subject, the study will have to be updated as more information and data becomes available and climate change models become more robust.

EXISTING ADAPTATION MEASURES

FLOODING

Since 1991, land reclamation levels for new coastal reclamation sites have been set at a minimum of 1.25m above the astronomical tide. This would provide an adequate buffer against the projected highest sea level rise of 65cm by the end of the 21st Century.

The development of drainage infrastructure in Singapore, amounting to S$2 billion over the last 30 years, reduced flood prone areas from 3178ha in the 1970s to 79ha in 2009. PUB, Singapore's National Water Agency, will progressively reduce it further through the development and improvement of drainage infrastructure in Singapore (e.g. widening and deepening of drains and canals), the completion of the Marina Barrage, as well as other flood alleviation projects.

COASTAL LAND LOSS

A sea level rise of up to 65cm can result in some coastal erosion and land loss in Singapore, particularly as Singapore has a relatively flat coastline. Currently, about 70% to 80% of Singapore's coastal areas have hard wall or stone embankments, which help protect against coastal erosion.

The rest are natural areas such as beaches and mangroves. Singapore will look at adapting to sea level rise through the protection of our foreshore and coastal areas as necessary. Existing revetments (which protect against erosion) may have to be strengthened and reinforced while natural areas may have to be protected using different coastal defense systems.

WATER RESOURCE IMPACTS

A rise in sea level can also result in seawater flowing into some of Singapore's coastal reservoirs – a process known as saltwater intrusion. However, seawater intrusion into our reservoirs is unlikely as most of our reservoir dams are higher than the AR4's projected sea level rise and if necessary, the gate structures for the dams can be raised.

Rising global temperatures can also change rainfall patterns and affect the amount of water stored in reservoirs. The unpredictability in rainfall can cause difficulties in capacity planning of water resources. However, the introduction of NEWater and desalination, which are not rainfall dependent, has diversified and increased the resilience of our water supply, even during prolonged dry spells, though these new sources of water are more energy-intensive compared to the treatment of water in our reservoirs.

PUBLIC HEALTH IMPACT FROM RESURGENCE OF DISEASES

Singapore is situated in a region where vector-borne diseases, particularly dengue, are endemic. The National Environment Agency (NEA) is studying the linkage between climatic factors such as temperature, humidity and rainfall with dengue incidence. Preliminary results indicate that the incidence of dengue in Singapore correlates with changes in the ambient temperature.

To minimise dengue incidence, NEA has put in place an integrated regime comprising virus and mosquito surveillance as well as intensive source reduction to suppress the mosquito vector population.

HEAT STRESS

Singapore could experience warmer temperatures as a result of both climate change as well as the urban heat island effect. The urban heat island effect refers to the phenomenon whereby urban areas are warmer than rural areas, largely due to the replacement of natural land cover with pavement, buildings and other infrastructure. Higher annual temperatures can lead to greater use of air conditioning and increase Singapore's energy demand. They may also mean more frequent and severe episodes of warm weather, leading to increased occurrences of heat stress and discomfort, particularly among the elderly, the sick and those without access to air conditioning.

Measures that can lower ambient temperature include increasing the amount of greenery in the city (e.g. city parks, rooftop gardens, vertical greening in buildings) and modifying building layouts and designs (e.g. using building materials with better thermal properties, lighter-coloured building surfaces, designing building interiors and exterior building layouts for better ventilation and maximising the wind tunnel effect).

Sungei Buloh Wetland Reserve

The Urban Redevelopment Authority (URA) and the National Parks Board (NParks) have been working closely together to plan and provide greenery islandwide, such as parks and green open spaces, and planting along roads and around developments. URA and NParks have also been promoting rooftop, vertical greenery and sky terraces on our residential and commercial buildings through planning guidelines and incentives. The Housing Development Board (HDB) is in the process of introducing rooftop greenery to multi-storey carparks and residential buildings where feasible.

IMPACTS ON ISLAND AND MARINE BIODIVERSITY

A rise in sea level can lead to loss of mangroves, which will represent a loss of biodiversity, and also further aggravate coastal erosion rates. A rise in seawater temperature as a result of global warming can also have a negative impact on marine life (e.g. coral bleaching).

NParks is looking into the role of nature reserves and urban greenery in carbon sequestration and is monitoring long-term tree diversity, tree growth and survival in marked study plots. The role of coral reefs around our southern islands is also acknowledged for sequestering carbon and mitigating storm damage and erosion.

Mangroves help to protect coasts against erosion and NParks is looking into ways of improving the mangrove habitats at some coastal areas. Singapore cannot prevent global trends from affecting seawater temperatures locally, but will seek to mitigate any additional influences on seawater quality through measures such as the release of cooling water or sedimentation.

FURTHER MEASURES TO ADAPT TO CLIMATE CHANGE

Climate change is a long-term phenomenon and its impacts will be felt for decades. The Ministry of National Development (MND) leads an inter-agency committee to review existing infrastructural adaptation measures. Government agencies will continue to collaborate to monitor and assess the possible impacts of climate change on Singapore, regularly review the sufficiency of Singapore's existing adaptation measures, and identify new measures where necessary.

CHAPTER FOUR

MITIGATION MEASURES

CHAPTER FOUR

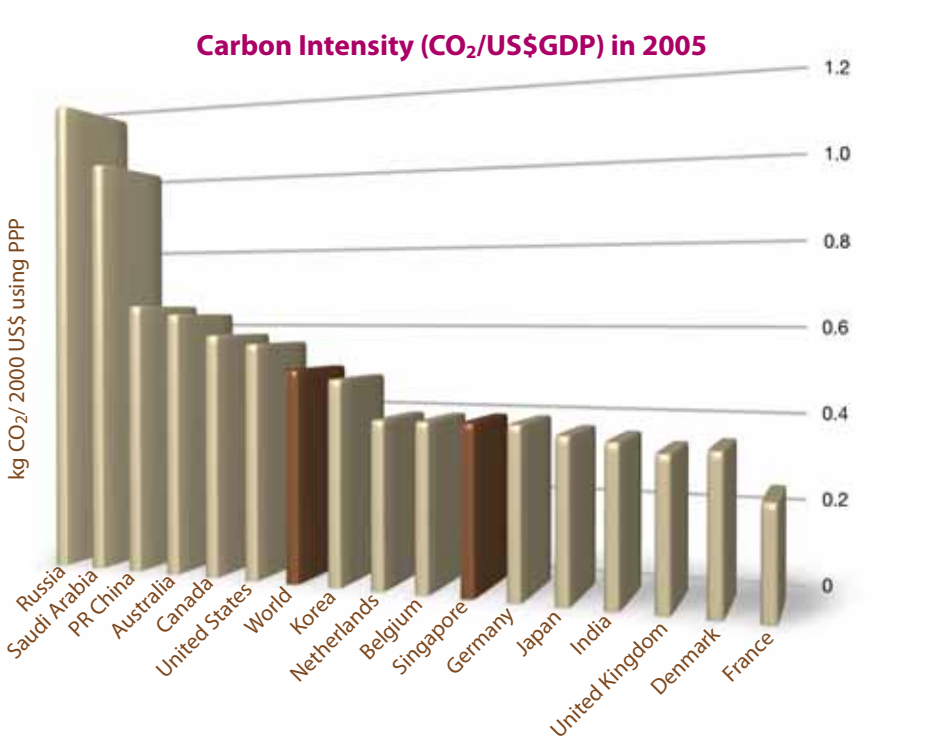
MITIGATION MEASURES

The predominant greenhouse gas in Singapore is carbon dioxide (CO_2) that arises from the combustion of fossil fuels. While Singapore faces many geographical constraints that limit our energy options, we have developed policies and implemented measures that help to mitigate the increase in greenhouse gas emissions.

CARBON INTENSITY

Singapore's small domestic market has necessitated an export-oriented economy, with the bulk of our industries manufacturing products for export rather than local consumption. As such, much of the energy used by our industries is used to manufacture products for export. Singapore's industries accounted for about half of Singapore's total energy use, most of it by key exporting industries such as refining, petrochemicals, pharmaceuticals and wafer fabrication. Singapore is also one of the five largest export refining centres in the world, where our three oil refineries which primarily serve the global market account for about 20% of Singapore's total energy use.

Despite having an export-oriented, energy-intensive economy, Singapore's carbon intensity (CO_2 per US$GDP at 2000 Purchasing Power Parity (PPP) prices) is below the world average, according to the International Energy Agency (IEA)[11]. In other words, we produce less carbon in the process of generating each dollar of GDP compared to many other countries.



[11] Source: IEA, 2005.

The Singapore Government has made a conscious decision not to subsidise energy production or consumption. Energy costs are passed through to consumers. Accurate price signals incentivise the optimal and efficient use of energy and discourage over-consumption. This ensures the free working of the market and allows selection of the most efficient and cost effective fuel source, option or technology.

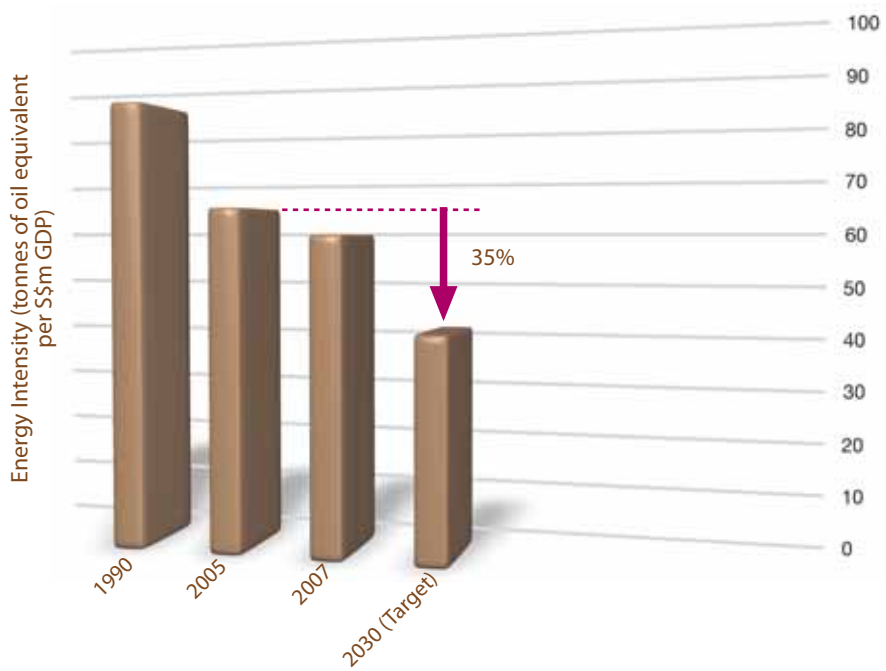
From 2001, we switched from fuel oil to natural gas – the cleanest form of fossil fuel – for electricity generation. Currently, about 80% of electricity is generated by natural gas using highly efficient combined cycle technology. The remaining electricity is generated by fuel oil and waste incineration. By 2007, our carbon intensity fell to 40% below 1990 levels, due to a switch to natural gas for power generation and ongoing improvements in energy efficiency.

ENERGY INTENSITY

Energy intensity refers to energy consumed per dollar GDP, and is an indication of how energy efficient a country is.

In 2009, Singapore pledged to undertake mitigation measures leading to a reduction of greenhouse gas emissions by 16% below 2020 Business-as-Usual (BAU) levels, contingent on a legally binding global agreement in which all countries implement their commitments in good faith. As part of efforts to meet this target, the Government is embarking on measures under the Sustainable Singapore Blueprint, which aims to improve our energy intensity (energy use by S$GDP) levels by 35% from 2005 levels by 2030.

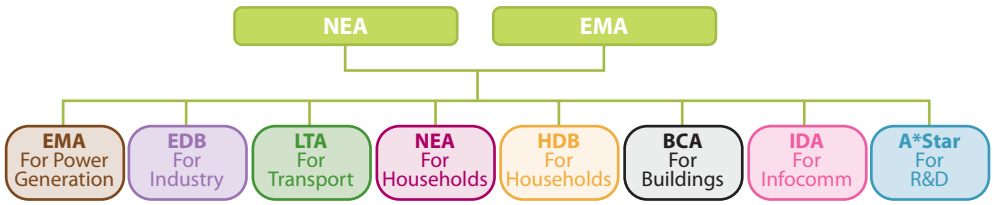
Singapore's Energy Intensity



ENERGY EFFICIENCY

Energy efficiency is a cost effective means of mitigating greenhouse gas emissions and reducing energy intensity. Although energy efficiency makes financial sense, energy efficiency measures may not be implemented due to market barriers such as the lack of information and capability.

The Energy Efficiency Programme Office (E^2PO)[12] was established to drive energy efficiency improvements in the various sectors of our economy. The E^2PO developed a national energy efficiency plan, Energy Efficiency Singapore (E^2 Singapore), to drive energy efficiency efforts across the different sectors of the economy. The E^2PO is a multi-agency committee co-led by the National Environment Agency (NEA) and the Energy Market Authority (EMA).



The following areas have been identified as part of a holistic energy efficiency strategy for Singapore:

i) Promoting adoption of energy efficient technologies and measures by addressing the market barriers to energy efficiency
ii) Building capability to drive and sustain energy efficiency efforts and to develop the local knowledge base and expertise in energy management
iii) Raising awareness to reach out to the public and businesses so as to stimulate energy efficient behaviour and practices
iv) Supporting research and development to enhance Singapore's capability in energy efficient technologies

The E^2 Singapore website is at www.e2singapore.gov.sg.

The ongoing and planned mitigation measures for the different sectors of the economy are described below.

a) Power Generation

LIBERALISATION OF ENERGY SECTOR

The Singapore electricity and piped gas markets have been liberalised and transformed from a vertically integrated and state-owned structure to competitive markets. Electricity and

[12] The agencies under E^2PO comprises the National Environment Agency (NEA), Energy Market Authority (EMA), Economic Development Board (EDB), Land Transport Authority (LTA), Housing Development Board (HDB), Building and Construction Authority (BCA), Infocomm Development Authority of Singapore (IDA) and the Agency for Science, Technology and Research (A*STAR).

gas operations were corporatized in 1995. Building upon this, the industry was further deregulated in 2000 through the appointment of an independent system operator and liberalisation of the electricity retail market. In 2001, the Energy Market Authority (EMA) was formed to regulate and promote competition in the electricity and gas industries. The establishment of the National Energy Market of Singapore (NEMS) in 2003 enabled electricity prices to reflect demand and supply changes more accurately.

By 2006, the second phase of electricity retail market liberalisation was completed, and about 75% of Singapore's total electricity demand was opened to retail competition.

While the retail sector for households and smaller users is not yet fully competitive, initiatives are being tested to enhance the sector's contestability through a pilot Electricity Vending System (EVS). The ongoing process of energy market liberalisation has resulted in greater efficiency and innovation. Restructuring has promoted competition and encouraged the industry to remain efficient as overall capacity grows over time.

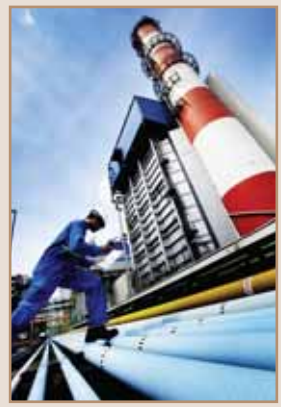
IMPROVEMENTS IN GENERATION EFFICIENCY

Due to market competition in the electricity market, power generation companies (gencos) have an incentive to be energy efficient. As a result, gross efficiency of power generation in Singapore increased from 39% in 2001 to 44% in 2007. Power companies operate their most efficient plants available while relegating the less efficient ones as standby units in order to compete in the electricity pool market for despatch. When old plants are replaced or new capacity added, power companies can be expected to seriously consider more efficient generating technologies. For instance, energy company PowerSeraya Ltd invested S$800 million to repower its existing oil-fired units with a more efficient gas-fired combined cycle cogeneration unit in 2007.

Further efforts to help improve the energy efficiency of power generation in Singapore include the use of cogeneration and trigeneration, which can achieve a generation efficiency of 70% or more in generating power and steam (and chilled water in the case of trigeneration). However, a combined demand for electricity and heating (and cooling in the case of trigeneration) is needed for such technologies to be viable. To maximise efficiency, government agencies such as the Economic Development Board (EDB), JTC Corporation and EMA plan industrial land and site facilities with cogeneration and trigeneration in mind, particularly for energy-intensive sectors such as power generation, petrochemicals and pharmaceuticals.

PowerSeraya Repowers to Natural Gas

In August 2007, Singapore energy company PowerSeraya Ltd announced plans to invest $800 million in a 800MW natural gas-fired cogeneration plant. The plant will replace three existing 250MW units firing heavy fuel oil, and will produce electricity and steam simultaneously using state-of-the-art technology.



This new facility is designed for increased thermal efficiency. It will deliver greater environmental benefits by decreasing PowerSeraya's overall carbon footprint by a further 10% beyond the 30% reduction it has already achieved over the past ten years.

Use of Trigeneration Facilities in Singapore

The Innovation for Environmental Sustainability (IES) fund has helped several firms in Singapore, including Pfizer Asia Pacific Pte Ltd and Schering-Plough Ltd, construct advanced trigeneration facilities in recent years.

Trigeneration facilities produce three types of utilities – for instance, electricity, steam, and chilled water – from a single integrated system, and increases overall energy efficiency by utilising more "'waste heat" compared to conventional systems.

Pfizer's 5MW trigeneration facilities is expected to reduce its CO_2 emissions by 17% annually, while Schering-Plough's 9.2MW facility will reduce its CO_2 emissions by an estimated 24%.

SWITCHING TO CLEANER FUELS

Singapore had traditionally been heavily reliant on oil as a fuel. Until 1992, fuel oil was the sole fuel for electricity generation. Singapore has been moving towards greater use of natural gas in place of fuel oil, which is the cleanest available fossil fuel that can meet our electricity needs. In this respect, much progress has been made recently. About 80% of Singapore's electricity is now generated using natural gas, compared to a world average of about 20%, according to the IEA.

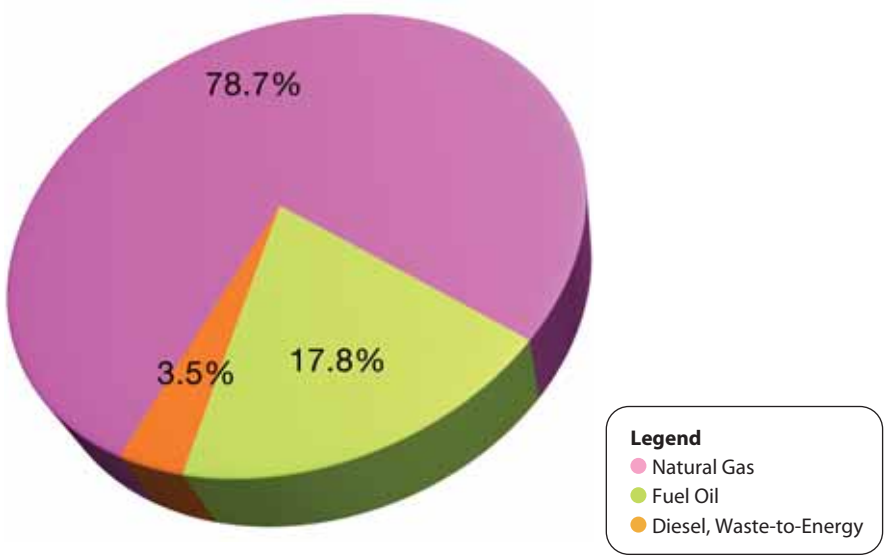
Within six years, the proportion of electricity generated by gas using highly efficient combined-cycle gas turbines in Singapore grew from 19% in 2000 to about 79% in 2007 as shown in the table below. This has led to significantly lower CO_2 emissions from the power sector, as natural gas emits 40% less CO_2 than fuel oil per unit of electricity generated. Singapore's grid emission factor is about 0.5kg CO_2/kWh.

Table: **Electricity Generated by Natural Gas**[13]

	2000	2001	2002	2003	2004	2005	2006	2007
Natural Gas as Percentage of Total Electricity Generation	19%	29%	44%	60%	69%	74%	78%	79%

The remaining electricity is generated by fuel oil or other energy sources is as shown.

Singapore Electricity Fuel Mix (2007)



[13] Source: EMA Annual Report.

Singapore's first Liquefied Natural Gas (LNG) terminal is scheduled to be operational by 2012, which will support the increased use of natural gas to help meet the increase in energy demand.

Liquefied Natural Gas in Singapore

The Government restructured and liberalised the electricity and gas markets in the 1990s, giving rise to market competition that has led to the rapid planting of combined-cycle gas turbines. As gas-fired power plants are amongst the most efficient and competitive power generation technologies, the economics of the market ensure that gas is a mainstay for our power generation. Today, about 80% of Singapore's electricity is generated from natural gas. Market competition and fuel switch from oil to gas have improved the competitiveness of electricity prices despite rising oil prices, helping to reduce air pollution and lowering Singapore's carbon intensity.

Our natural gas is supplied by Malaysia and Indonesia through pipelines. To meet future demand for natural gas, Singapore will import LNG from 2013 onwards.

Singapore has appointed BG Asia Pacific Pte Ltd to supply three million tonnes per annum of LNG from Egypt, Trinidad & Tobago, and Australia. Singapore's first LNG terminal on Jurong Island will be developed by the Government through the Singapore LNG Corporation Pte Ltd (a subsidiary of the EMA).

PROMOTING RENEWABLE ENERGY

Given Singapore's limited land area, Singapore lacks the natural endowments necessary to make use of non-fossil energy alternatives to meet its needs. As such, Singapore is an "alternative energy-disadvantaged" country, where most alternative energy sources are not available in Singapore.

Solar energy is thus far the only renewable energy source which offers some potential for Singapore. Hence, our efforts in promoting renewable energy are focused on research and development and test-bedding of solar energy technologies to improve their performance and cost-effectiveness. This includes setting up research institutes, providing funds as well as test-bedding platforms, which are elaborated in Chapter 5.

Government agencies are working together to review the policies pertaining to distributed electricity generation using renewable energy sources in Singapore while at the same time, ensuring that this will not cause disruption to our electricity network. This will serve to encourage take-up of small-sized renewable energy generation systems by companies and individuals.

Waste-to-Energy

As a small city state, Singapore has limited land available for waste disposal. Our policy for solid waste management is to reduce the volume of waste that goes to the landfill by incinerating all incinerable waste at the waste-to-energy plants. Less than 10% of our waste, which is non-incinerable, goes to the landfill. There are a total of 4 waste-to-energy plants in Singapore and they contribute 2-3% of our electricity supply.

b) Industry

Singapore is one of the top oil refining centres and oil trading hubs in the world, and our refineries support an ever-growing petrochemicals industry chain. We also account for 10% of the global market for semiconductor wafer output.

There are existing technologies and practices that can be implemented to improve the energy efficiency in industry. While these technologies and practices can be cost effective and result in energy cost savings for the companies, there are often market barriers that constrain their adoption. We are working with companies to address these barriers, and have put in place schemes to encourage companies to:

i) Design their facilities to be energy efficient;
ii) Use energy efficient equipment;
iii) Have trained personnel who can identify and implement energy efficient measures.

The global concern with climate change also brings with it new business opportunities. These include the export of carbon-efficient technologies to support sustainable development in other countries and the provision of carbon services such as carbon trading. These opportunities

match Singapore's environmental, engineering, and financial expertise, and government agencies are working with local industries to seek out such opportunities. This will contribute to global efforts in mitigating climate change.

DESIGN FOR EFFICIENCY SCHEME

To help new industrial facilities in Singapore incorporate energy efficiency considerations at the design stage, a Design for Efficiency scheme was launched in 2008. It is a fund that co-funds design workshops for new industrial developments to meet high standards of energy efficiency.

ENERGY EFFICIENCY IMPROVEMENT ASSISTANCE SCHEME

In April 2005, a S$10 million Energy Efficiency Improvement Assistance Scheme (EASe) was launched to co-fund the cost of energy audits. Under EASe, funding of up to 50% of the cost for energy audits, subject to a cap of S$200,000, is provided to any Singapore registered company with a building or manufacturing facility in Singapore. As of end Jan 2010, 169 companies in the power, industry and building sectors obtained grants under EASe to conduct energy audits. The recommended energy efficiency measures from the energy audits are projected to result in annual energy savings of 331,422MWh and 168kt of CO_2 for the companies, if implemented.

GRANT FOR ENERGY EFFICIENT TECHNOLOGIES

To further encourage companies in Singapore to adopt energy efficient technologies and equipment, a Grant for Energy Efficient Technologies was set up in November 2008. This grant provides funding for companies to offset part of their investment cost for energy efficient equipment.

SINGAPORE CERTIFIED ENERGY MANAGER TRAINING GRANT

To help equip facility owners and technical staff with the necessary knowledge and skills to manage energy services within their facilities, a Singapore Certified Energy Manager Training Grant was introduced in September 2008 to equip facility owners and technical staff with the necessary knowledge and skills to manage energy services within their facilities. Singapore will also make the appointment of energy managers mandatory for large energy-consuming facilities within the next three years.

c) Transport

Improving the energy efficiency of the transport sector is achieved through the following key strategies:

i) Promoting the use of public transportation and making it a choice mode for commuting;
ii) Managing road usage;
iii) Improving fuel economy;
iv) Promoting green vehicles; and
v) Promoting fuel-efficient driving habits.

Mass Rapid Transit System (MRT)

PROMOTING THE USE OF PUBLIC TRANSPORT

Public transport is the most efficient and sustainable form of motorised transport. Singapore targets to achieve a public transport modal split of 70% in the morning peak period by 2020, up from the current 63%. The merits of promoting public transport can be seen from a comparison of the relative energy use by various modes of transport. It is estimated that a car carrying only the driver uses nine times the energy used by a bus and twelve times that used by a train per passenger kilometre transported.

We aim to make public transport a choice mode to attract even car owners to consider using it for their daily commute. We will improve the reliability, frequencies and speed of bus services, while reducing waiting and travelling time. We will continue to expand our Rapid Transit System (RTS), aiming to double our rail network from 142km in 2008 to 278km by 2020. The integration of the public transport network will be improved, to make transfers as seamless as possible, and integrated travel information will be provided to facilitate commuters in planning their journey.

MANAGING ROAD USAGE

By effectively managing road usage, we seek to reduce congestion and improve the efficiency of our transportation system. This goes towards reducing vehicular emissions. The Vehicle Quota System (VQS) and Electronic Road Pricing (ERP) are two of our main strategies of promoting the use of public transport as a viable alternative and to limit car ownership and usage. This helps to minimise vehicle emissions and congestion on the roads, and hence reduces fuel wasted and pollution caused by vehicles caught in grid-lock.

Besides the ERP, Singapore leverages technology to maximise the capacity of the road network, through systems such as the Green Link Determining System (GLIDE) and the Expressway Monitoring and Advisory System (EMAS). GLIDE effectively increases traffic throughput at our junctions by monitoring real-time traffic flow, while EMAS ensures that incidents on expressways are cleared quickly, thereby minimising congestion.

Vehicle Quota System

The VQS was implemented on 1 May 1990 to regulate Singapore's vehicle population. Under the VQS, LTA determines the number of vehicles that are allowed to be registered for use in Singapore, allowing the vehicle population in Singapore to grow at a sustainable rate.

LTA determines the number of vehicles that are allowed to be registered in a given six-month period, taking into account the prevailing traffic conditions and the number of vehicles that have been taken off the road permanently in the prior 6-month period.

Based on the number of new vehicles allowed, LTA releases that number of Certificates of Entitlement (COEs) into the market. Potential buyers then proceed to bid for these COEs, which will entitle them to own a vehicle for a fixed number of years.

Electronic Road Pricing

Congestion pricing was first introduced in Singapore in 1975 to control congestion within the city centre. Known as the Area Licensing Scheme (ALS), motorists entering the city had to purchase and display a label. Although it did discourage some drivers from driving into the city, it was not user-friendly and labour intensive to enforce. It was therefore difficult to extend the scheme to other places or time periods where congestion had built up.

In September 1998, the ERP was implemented as an innovative, efficient and cost-effective solution to manage travel demand in ensuring that traffic on our roads remains smooth-flowing. Each vehicle is installed with an electronic In-Vehicle Unit (IU). The driver inserts a pre-paid stored-value smartcard known as a cashcard with sufficient balance into the IU at the start of the journey. Each time the vehicle passes under an ERP gantry when it is operational, a pre-determined charge is deducted from the cashcard.

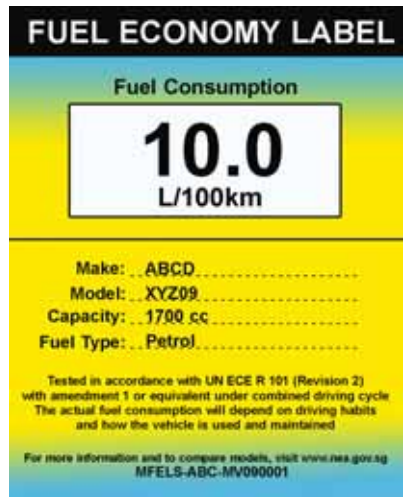
The ERP aims to keep traffic speeds on a road within an optimal speed range, that is the road is carrying its maximum capacity and traffic can still flow smoothly. The ERP is implemented on roads where travel demand has built up to a point that the traffic speeds on the road fall below this optimal speed range, and traffic conditions degenerate quickly into start-stop conditions. It aims to discourage excessive numbers of motorists from using the road so that traffic conditions can return to optimal speeds. The ERP is a targeted way of managing traffic congestion as it charges motorists only when they contribute to congestion.

The ERP system was one of the first of its kind to be implemented in the world and on such a scale. Similar systems have since been implemented in cities such as London and Stockholm. From the environmental viewpoint, keeping traffic flowing smoothly minimises the wastage of time and fuel, and reduces pollution caused by vehicles in grid-lock. Ensuring a congestion-free road network facilitates the efficient movement of people and goods, and supports our economic growth.

IMPROVING FUEL ECONOMY

The Fuel Economy Labelling Scheme (FELS) was launched in 2003 as a voluntary programme with the aim of providing buyers of passenger cars with fuel economy information at the point of sale. As of end 2007, less than 20% of all vehicle models in the market had participated in FELS. The effectiveness of FELS was limited, as consumers were only able to compare the fuel economies of a limited range of vehicle models.

To improve the effectiveness of FELS, Singapore introduced mandatory Fuel Economy labelling for passenger cars and light goods vehicles in April 2009. All automobile retailers are now required to display the fuel economy labels of passenger car and light goods vehicles models at the showroom. All consumers are thus able to take the fuel economy of the vehicles into consideration as part of their purchasing decisions.



Fuel Economy Label

PROMOTING GREEN VEHICLES

To encourage the purchase of green vehicles[14], a Green Vehicle Rebate (GVR) has been in place since 2001. The GVR incentivises the adoption of greener, cleaner vehicles by narrowing the cost differential between green vehicles and equivalent, conventional models. Green passenger vehicles enjoy a rebate of 40% of the open market value of the vehicle, while electric motorcycles enjoy a rebate of 10%. The GVR is also applicable to businesses, and green commercial vehicles enjoy a rebate of 5% of their open market value. The rebates are used to offset part of the registration fees for the vehicle. Since 2005, the number of green vehicles has increased substantially from about 140 to more than 7,000 at the end of 2009. Singapore will continue to encourage more motorists to switch to green vehicles which are cleaner and more fuel-efficient.

PROMOTING FUEL-EFFICIENT DRIVING HABITS

Fuel-efficient driving habits, such as avoiding hard braking and acceleration, maintaining the appropriate tyre pressure and reducing idling, can save up to 10% of fuel without any increase in travel time. These habits also result in safer driving, better comfort, less pollution and less noise. Singapore will promote such fuel-efficient driving habits to motorists more actively.

[14] Green vehicles include hybrid, electric, and compressed natural gas (CNG) vehicles.

d) Buildings

Most of the electricity used by buildings in Singapore is for air conditioning (40-50%), mechanical ventilation (about 20%) and lighting (15-20%). Results from energy audits co-funded by NEA have shown that there is room for improvement in terms of energy efficiency of buildings in Singapore.

BUILDING REGULATIONS

Although a green building may cost more to build, it is more cost effective over the life cycle of the building, and energy savings of 20-30% are possible. To promote the construction of energy efficient green buildings in Singapore, all new buildings and existing ones that undergo major retrofitting were required by April 2008 to meet minimum requirements on environmental sustainability that are equivalent to the Green Mark certified standards.

To improve energy efficiency in buildings, minimum standards for building insulation were set to limit the amount of heat gained by an air conditioned building through its roofs, external walls and windows. Such requirements are set for both commercial and residential buildings and are regularly reviewed.

A new standard on Energy Efficiency for Building Services and Equipment was announced in January 2007. This standard sets minimum energy efficiency standards for building equipment such as air conditioning equipment, water heaters, electric motors and high efficiency lightings. Air conditioning chillers which comply with the new standard use up to 30% less energy.

BUILDING LABELS

The Energy Smart Building Labelling Scheme was launched in December 2005 to accord recognition to existing office buildings with good energy performance. Such labels encourage developers to build energy efficient, environmentally-friendly buildings. This Scheme was extended to hotels and shopping malls in 2007 and 2009 respectively.

Energy Smart Building Labels

The Green Mark scheme was introduced in January 2005 to recognise new buildings designed with environmentally friendly features. Buildings are awarded Certified, Gold, GoldPLUS or Platinum rating depending on the points scored on a set of criteria, including energy and water efficiency. Since 2008, all new buildings and existing buildings undergoing major retrofitting works with a gross floor area of above 2,000m^2 have to meet the Green Mark Certified standard.

GREEN BUILDING DESIGN GUIDE

A Green Building Design Guide was produced for air conditioned buildings. It compiles the design features of buildings that have achieved Green Mark, giving useful information on environmentally sustainable building designs as well as ways to improve energy efficiency.

National Library Building Takes the Lead in Energy Efficiency

The National Library Building was awarded both the Energy Smart Building Label and the Green Mark Platinum Standard.

Vegetation and landscaping are utilised to improve the indoor thermal environment and thermal performance of the building.

Through the use of light sensors, the lighting control system switches off lighting when there is sufficient natural light to illuminate the building interior.

About two thirds of the building facade is double-glazed with special glass to minimise heat transfer. The building is heavily shaded to reduce solar heat gain through the facade. The air conditioning system is also configured to ensure optimal energy performance under varying load conditions.

GOVERNMENT TAKING THE LEAD

The public sector is a significant energy consumer in the buildings sector, accounting for approximately 19% of the electricity consumption of non-residential buildings in Singapore. Taking a leadership role, all public sector agencies have, since April 2007, incorporated the Green Mark certification into the procurement and design requirements for new and retrofitted

Government building developments. All large, air conditioned government office buildings as well as polytechnics and Institutes of Technical Education are to undergo energy audits by 2010. Buildings such as the Environment Building won the top ASEAN award for energy efficient buildings in 2007. From 2011, ministries and organs of state are to set overall energy saving targets.

PROMOTING ENERGY AUDITS AND ENERGY EFFICIENCY MEASURES

The EASe scheme, and Grant for Energy Efficient Equipment and Systems described in the Industry section also apply to buildings.

e) Households

The bulk of energy consumption for the households sector is used for air conditioners and refrigerators, followed by appliances such as consumer electronics (e.g. TVs, DVD players, computers), lighting and water heating.

Mandatory Energy Labelling Scheme

MANDATORY ENERGY LABELLING SCHEME

Mandatory energy labelling keeps consumers informed of the energy efficiency of an appliance, helping them choose a more energy efficient model.

Energy Label

From January 2008, all household air conditioners and refrigerators, which together account for about 50% of the average household electricity bill, sold in Singapore are required to carry an energy label. The Scheme was extended to household clothes dryers from April 2009. Singapore is studying the possibility of extending the scheme to other appliances.

MINIMUM ENERGY PERFORMANCE STANDARDS

Minimum Energy Performance Standards (MEPS) ensure that all models of an appliance sold in a country meet a basic level of energy efficiency, eliminating energy inefficient appliances from the market. Such standards are already in place in many countries, particularly for energy intensive appliances. Singapore will be imposing MEPS on household air conditioners and refrigerators by 2011.

ELECTRICITY VENDING SYSTEM

Singapore is studying the feasibility of a scheme called the Electricity Vending System (EVS). The EVS will enable consumers to buy electricity from any electricity retailer and allows consumers to monitor their electricity consumption figures by the half-hour. By being more aware of such patterns, consumers in Singapore can reduce their electricity bills through more prudent use of electricity.

10% ENERGY CHALLENGE

In April 2008, Singapore launched the 10% Energy Challenge, a national public awareness campaign challenging households to reduce their electricity consumption by at least 10% by adopting simple energy saving habits. A 10% cut in total household electricity consumption translates into about S$160 million savings per annum based on 2008 consumption and electricity tariff rates.

10% Energy Challenge Fair

Households can reduce their electricity bill by 10% or more by adopting simple energy saving habits at home, such as by turning off standby power, raising the thermostat temperature of their air conditioner, using less air conditioning and switching to energy efficient appliances and energy-saving light bulbs.

To encourage Singaporeans to adopt more energy efficient lifestyles, a list of energy saving tips has been disseminated to all households via an energy efficiency kit, publicity flyers, mass media and a 10% Energy Challenge website (www.e2singapore.gov.sg/energy-challenge.html).

CLEAN DEVELOPMENT MECHANISM

DESIGNATED NATIONAL AUTHORITY

The Clean Development Mechanism (CDM) of the Kyoto Protocol allows greenhouse gas emissions reductions from registered projects implemented in non-Annex I countries to be used to offset emissions of Annex I countries. NEA, as the Designated National Authority for CDM, is responsible for ensuring that CDM projects in Singapore support sustainable development and for issuing letters of approval to support CDM project registration.

Sustainable Development (SD) Criteria for CDM Projects are as follows:

i) Environmental Sustainability

a) Project meets Singapore's environmental protection requirements, standards and regulations

b) Project produces real and measurable reductions in greenhouse gas emissions

ii) Economic Sustainability

a) Project utilises more efficient (energy efficient, resource efficient) technology than common industrial practice

b) Project results in technology transfer and/or capacity building in greenhouse gas emissions emission reduction technologies

iii) Social Sustainability

a) Project helps to improve quality of life by creating opportunities for jobs, job enhancement, etc

CDM DOCUMENTATION GRANT

To promote CDM projects in Singapore, a fund was set up to award grants to companies that engaged carbon consultancy services to develop CDM documentation. The grant co-funds up to 50% of the qualifying cost of engaging a carbon consultant to develop new methodologies

and project design documents needed for CDM project registration. The grant aims to increases the uptake of CDM projects in Singapore.

EIGHTH UNFCCC CDM DESIGNATED NATIONAL AUTHORITIES (DNA) FORUM

Singapore hosted the eighth UNFCCC CDM Designated National Authorities (DNA) Forum on 26 to 28 October 2009.

The DNA Forum, attended by 94 DNA representatives from 78 countries, provided a platform for DNA delegates to exchange views, share their experiences relating to the CDM and bring ideas to the attention of the CDM Executive Board to enhance the CDM process. The Forum also included an industry interaction session on the third day to allow knowledge sharing and networking between the DNA delegates and 109 private sector representatives.

CARBON FORUM ASIA

Singapore played host to Carbon Forum Asia, a carbon market trade fair and conference whose inaugural event was held from 6-7 November 2007. The fair provides a platform for potential CDM project financing opportunities to be explored.

Organised by the International Emissions Trading Association and Koelnmesse, Carbon Forum Asia was hosted by the Sustainable Energy Association of Singapore and supported by various government agencies including EDB, International Enterprises Singapore, and NEA. Over 1,000 participants from 46 countries gathered in Singapore during the inaugural event to explore business opportunities in emission reductions, as well as to engage with key market players in the Asian carbon market. The Second and Third Carbon Forum Asia were held in Singapore from 12-13 November 2008 and 26-27 October 2009 respectively.

CHAPTER FIVE

RESEARCH, DEVELOPMENT AND INNOVATION

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RESEARCH, DEVELOPMENT AND INNOVATION

Singapore is a densely-populated, resource-scarce urban city-state, with limited access to alternative energy resources. Continued efforts in research and development are necessary to generate cost-effective innovative solutions that can enable Singapore to overcome its unique constraints and ensure its long-term environmental sustainability.

Research into clean and renewable energy can improve the current state of technology and lower costs to a level that will facilitate domestic adoption and reduce reliance on fossil fuels. The Singapore Government is taking an active role in driving research and development investment, with the set-up of several programmes and funds dedicated to clean and environmental technologies.

RESEARCH

CLEAN ENERGY

As Singapore is energy-scarce, clean alternative energy sources have been the focus of significant research and development efforts.

The Economic Development Board (EDB) set up the inter-agency **Clean Energy Programme Office (CEPO)** to grow the Clean Energy industry in Singapore by focusing on cluster development, technology development and internationalisation, with an emphasis on solar energy. The S$50 million Clean Energy Research Programme (CERP) funded by the CEPO aims to kick start research and development activities in Clean Energy in Singapore. CERP supports both upstream and downstream commercially-relevant research and development efforts through a competitive funding approach.

The **Solar Energy Research Institute of Singapore (SERIS)** was launched at the National University of Singapore in 2008. It is led by Professor Joachim Luther, the former Director of the world renowned Fraunhofer Institute of Solar Energy Systems. With an investment of S$130 million over five years, this institute will conduct world-class industry-oriented research and development and train specialist manpower for the solar energy sector.

GREEN BUILDINGS

In 2007, the Ministry of National Development set aside S$50 million over a five-year period for a new **Research Fund for the Built Environment**. Part of this fund will go towards intensifying research and development efforts in green building technologies and energy efficiency.

TEST-BEDDING

Emerging environmental technologies tend to be more expensive, so it is not cost-effective to implement their use widely in the short-term. However, in the longer-term, further innovation and greater scale may drive costs down. Test-bedding thus constitutes an important phase where new technologies can be tested for their effectiveness in Singapore's context, and improved upon to ensure their suitability for wider scale application as costs fall.

There are several programmes in place which support the test-bedding of new environmentally sustainable energy solutions:

INNOVATION FOR ENVIRONMENTAL SUSTAINABILITY (IES) FUND

To encourage test-bedding of new technologies, the National Environment Agency (NEA) set up the S$20 million IES Fund in 2001. The IES fund provides financial grants for companies to test-bed innovative technologies which contribute to environmental sustainability.

For instance, IES funding of S$1 million was provided to testbed building integrated photovoltaics (BIPV) at the Biopolis (Singapore's biotechnology hub). BIPV is an innovative PV technology in which solar PV cells are integrated into the facade of buildings.

CLEAN ENERGY RESEARCH & TEST-BEDDING PROGRAMME

In August 2007, a S$17 million Clean Energy Research & Testbedding (CERT) Programme was launched by the CEPO. Under this programme, facilities and buildings in Singapore can be used as a "field laboratory" for clean energy technologies to be tested and integrated, prior to commercialisation.

MARKET DEVELOPMENT FUND

The S$5 million Market Development Fund was launched by the Energy Market Authority (EMA) in May 2009 to facilitate testbedding of non-traditional generation technologies that have significant value in the electricity market, as well as other ideas or technologies that have development potential in the electricity market.

SINGAPORE INITIATIVE ON NEW ENERGY TECHNOLOGY

To provide a platform for the development and testbedding of clean energy technologies and sustainable energy solutions, the Singapore Initiative on New Energy Technology (SINERGY) Centre was established. The SINERGY Centre works with independently-funded research groups from both the public and private sectors to develop expertise in systems integration and evaluation of technologies, with the eventual goal of providing this expertise in the form of consultancy services to address issues such as energy efficiency, fuel as well as grid management.

Solar panels at Marina Barrage

SOLAR CAPABILITY SCHEME (SCS)

The EDB's S$20 million Solar Capability Scheme (SCS) was launched in 2008 to enhance capabilities among system integrators and developers of solar energy systems. The SCS will offset up to 30% of the total capital cost of solar technology, capped at S$1 million per project. Buildings which meet a minimum benchmarking system or are undergoing extensive retrofits are eligible for consideration.

CHAPTER SIX

INTERNATIONAL COOPERATION

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INTERNATIONAL COOPERATION

Given the global nature of the issue of climate change, domestic efforts alone will not be sufficient. A collective effort by the international community is necessary if we are to effectively address climate change, and every country will need to play its part. Singapore is doing its part to support international, regional, and national efforts to address the challenges of climate change.

INTERNATIONAL COOPERATION

The UNFCCC arose from the Rio Earth Summit of 1992. The UNFCCC sets the framework for governments to cooperate on addressing climate change, and paved the way for the Kyoto Protocol. Singapore ratified the UNFCCC in 1997, and acceded to the Kyoto Protocol in 2006.

REGIONAL COOPERATION

Singapore supports the APEC[15] aspirational goal to increase forest cover in the APEC region by at least 20 million ha by 2020, as well as to reduce deforestation. Singapore also supports the APEC-wide regional goal of a reduction in energy intensity of at least 25% by 2030 from 2005 levels. In November 2007, Singapore hosted the thirteenth ASEAN[16] Summit and the third East Asia Summit (EAS), regional leaders declared their resolve to work closely with one another on a fair, flexible, and comprehensive multilateral agreement in addressing climate change beyond 2012. The third EAS chaired by Singapore also agreed to support the work towards achieving a common understanding on a long-term aspirational global emissions reduction goal to pave the way for a more effective post-2012 international arrangement.

BILATERAL COOPERATION

On a bilateral basis, Singapore has collaborated with Indonesia to develop a Master Plan to deal with land and forest fires in Indonesia's Jambi province, which was completed in April 2007. The Master Plan calls for the use of modern technology and processes to create a more sustainable alternative livelihood for small-time farmers in Jambi, such as aquaculture. This will help remove the need for such farmers to burn large areas of peatland forests in Jambi in order to prepare the land for farming, releasing large quantities of CO_2 into the atmosphere in the process. The Master Plan is currently being implemented by Jambi Provincial Government and Indonesia's State Ministry of Environment, with technical assistance from Singapore for certain programmes. The Master Plan can be used as a model to be replicated in other fire-prone districts in our ASEAN region.

[15] Asia-Pacific Economic Cooperation.
[16] Association of Southeast Asian Nations.

ANNEX

SINGAPORE'S 2000 GREENHOUSE GAS INVENTORY BASED ON REVISED 1996 IPCC METHODOLOGY

ANNEX
SINGAPORE'S 2000 GREENHOUSE GAS INVENTORY BASED ON REVISED 1996 IPCC METHODOLOGY

MODULE		ENERGY						
SUBMODULE		CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)						
COUNTRY		SINGAPORE						
YEAR		2000						
			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	0	41832	0.020		327.841	41503.79
		Orimulsion	0	0	0		0	0.00
		Natural Gas Liquids	0	0.014	0.27		0	-0.26
	Secondary Fuels	Gasoline	0	4147.373	7453.714		28	-3334.34
		Jet Kerosene	0	927.401	4504.718		26.48	-6304.21
		Other Kerosene	0	372.024	1126.676		27.062	-781.71
		Shale Oil	0	0	0		0	0
		Gas / Diesel Oil	0	3782.365	11468.511		85.834	-7771.98
		Residual Fuel Oil	0	28087.87	9372.059		45.156	1537.07
		LPG	0	0.216	674.231		-2.914	-671.10
		Ethane	0	0	0		0	0
		Naphtha	0	1576.911	2988.098		-26.315	-1384.87
		Bitumen	0	21.45	1166.959		-8.646	-1136.86
		Lubricants	0	213.38	1283.213		49.054	-1118.89
		Petroleum Coke	0	9.395	0.329		0	9.07
		Refinery Feedstocks	0	0	0		-9.644	9.64
		Other Oil	0	46.057	195.111		-5.078	-143.98
Liquid Fossil Totals								
Solid Fossil	Primary Fuels	Anthracite	0	0.125	0.013		0	0.11
		Coking Coal	0	0	0		0	0
		Other Bit. Coal	0	0.079	0.007		0	0.07
		Sub-bit. Coal	0	0.04	0.025		0	0.02
		Lignite	0	0	0		0	0
		Oil Shale	0	0.148	0.015		0	0.13
		Peat	0	0.064	0.065		0	0
	Secondary Fuels	BKB & Patent Fuel	0	0.000	0.000		0	0
		Coke Oven/Gas Coke	0	0.082	0.186		0	-0.104
Solid Fuel Totals								
Gaseous Fossil		Natural Gas (Dry)	0	0.003	0.000		0	0
Total								
Biomass total								
		Solid Biomass						0
		Liquid Biomass						0
		Gas Biomass						0

Note: Data on international bunker fuels are reported in a separate memo to the UNFCCC as emissions from such bunker fuels should not be accrued to Singapore.

MODULE	ENERGY						
SUBMODULE	CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)						
COUNTRY	SINGAPORE						
YEAR	2000						
			STEP 2		STEP 3		
			G Conversion Factor (TJ/Unit)	H Apparent Consumption (TJ)	I Carbon Emission Factor (t C/TJ)	J Carbon Content (t C)	K Carbon Content (Gg C)
FUEL TYPES				H=(FxG)		J=(HxI)	K=(J/1000)
Liquid Fossil	Primary Fuels	Crude Oil	42.71	1,772,626.91	20.0	35,452,538.27	35,452.54
		Orimulsion		0.00		0.00	0.00
		Natural Gas Liquids	43.12	-11.04	17.2	-189.87	-0.19
	Secondary Fuels	Gasoline	44.80	-149,378.48	18.9	-2,823,253.21	-2,823.25
		Jet Kerosene	44.59	-281,104.81	19.5	-5,481,543.86	-5,481.54
		Other Kerosene	44.75	-34,981.70	19.6	-685,641.35	-685.64
		Shale Oil	36.00	0.00	20.0	0.00	0.00
		Gas / Diesel Oil	43.33	-336,759.89	20.2	-6,802,549.85	-6,802.55
		Residual Fuel Oil	40.19	61,774.80	21.1	1,303,448.35	1,303.45
		LPG	47.31	-31,749.79	17.2	-546,096.36	-546.10
		Ethane	0.00	0.00	16.8	0.00	0.00
		Naphtha	45.01	-62,333.09	20.0	-1,246,661.77	-1,246.66
		Bitumen	40.19	-45,690.52	22.0	-1,005,191.53	-1,005.19
		Lubricants	40.19	-44,968.07	20.0	-899,361.37	-899.36
		Petroleum Coke	31.00	281.05	27.5	7,728.77	7.73
		Refinery Feedstocks	44.80	432.05	20.0	8,641.02	8.64
		Other Oil	40.19	-5786.40	20.0	-115727.91	-115.73
Liquid Fossil Totals							
Solid Fossil	Primary Fuels	Anthracite		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	9.40	1.25	29.1	36.38	0.036
		Peat		0.00		0.00	0.00
	Secondary Fuels	BKB & Patent Fuel		0.00		0.00	0.00
		Coke Oven/Gas Coke	27.21	-2.83	29.5	-83.48	-0.083
Solid Fuel Totals					0.00		0.00
Gaseous Fossil		Natural Gas (Dry)	43.12	0.129	15.3	1.979	0.002
Total				842,349.58		17,166,094.21	17,166.11
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

MODULE		ENERGY				
SUBMODULE		CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)				
COUNTRY		SINGAPORE				
YEAR		2000				
		STEP 4		STEP 5		STEP 6
		L Carbon Stored (Gg C)	M Net Carbon Emissions (Gg C)	N Fraction of Carbon Oxidised	O Actual Carbon Emissions (Gg C)	P Actual CO_2 Emissions (Gg CO_2)
FUEL TYPES			M=(K-L)		O=(MxN)	P=(Ox[44/12])
Liquid Fossil	Primary Fuels	Crude Oil	0	35452.54	0.99	35098.01	128692.71
		Orimulsion	0	0	0.99	0	0
		Natural Gas Liquids	0	-0.19	0.99	-0.19	-0.69
	Secondary Fuels	Gasoline	0	-2823.25	0.99	-2795.02	-10248.41
		Jet Kerosene	0	-5481.54	0.99	-5426.73	-19898.00
		Other Kerosene	0	-685.64	0.99	-678.78	-2488.88
		Shale Oil	0	0	0.99	0	0
		Gas / Diesel Oil	0	-6802.55	0.99	-6734.52	-24693.26
		Residual Fuel Oil	0	1303.45	0.99	1290.41	4731.52
		LPG	0.10	-546.20	0.99	-540.74	-1982.71
		Ethane	0	0	0.99	0	0
		Naphtha	2025.45	-3272.11	0.99	-3239.39	-11877.77
		Bitumen	97.37	-1102.56	0.99	-1091.53	-4002.28
		Lubricants	90.94	-990.31	0.99	-980.40	-3594.81
		Petroleum Coke	0	7.73	0.99	7.65	28.06
		Refinery Feedstocks	0	8.64	0.99	8.55	31.37
		Other Oil	0	-115.73	0.99	-114.57	-420.09
Liquid Fossil Totals							
Solid Fossil	Primary Fuels	Anthracite	0	0		0	0
		Coking Coal	0	0		0	0
		Other Bit. Coal	0	0		0	0
		Sub-bit. Coal	0	0		0	0
		Lignite	0	0		0	0
		Oil Shale	0	0.036	0.99	0.036	0.132
		Peat	0	0		0	0
	Secondary Fuels	BKB & Patent Fuel	0	0		0	0
		Coke Oven/Gas Coke	0	-0.083	0.99	-0.083	-0.303
Solid Fuel Totals							
Gaseous Fossil		Natural Gas (Dry)	0	0.002	0.995	0.002	0.007
Total			**2213.86**	**14952.23**		**14802.71**	**54276.59**
Biomass total			0	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

MODULE	ENERGY							
SUBMODULE	CO_2 FROM ENERGY SOURCES							
COUNTRY	SINGAPORE							
YEAR	2000							
Estimating Carbon Stored In Products	A Estimated Fuel Quantities	B Conversion Factor (TJ/Unit)	C Estimated Fuel Quantities (TJ)	D Carbon Emission Factor (t C/TJ)	E Carbon Content (t C)	F Carbon Content (Gg C)	G Fraction of Carbon Stored	H Carbon Stored (Gg C)
FUEL TYPES			C=(AxB)		E=(CxD)	F=(E/1000)		H=(FxG)
Naphtha	3000	45.01	135030.00	20	2700600.00	2700.60	0.75	2025.45
Lubricants	226.286	40.19	9094.43	20	181888.52	181.89	0.5	90.94
Bitumen	110.120	40.19	4425.73	22	97366.16	97.37	1	97.37
Coal Oils and Tar (from Coking Coal)			0		0	0	0.75	0
Natural Gas			0		0	0	0.33	0
Gas/Diesel Oil			0		0	0	0.5	0
LPG	0.160	47.31	7.57	17.2	130.20	0.13	0.8	0.10
Ethane			0		0	0	0.8	0
Other Fuels			0		0	0		0

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)					
COUNTRY	SINGAPORE					
YEAR	2000					
	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			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	66.73	43.33	2,891.54	20.2	58,409.13	58.41
Residual Fuel Oil	5,427.80	40.19	218,143.40	21.1	4,602,825.71	4,602.83
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	1.177963	41868	49,318.95	15.3	754,580.01	754.58
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			**270,353.89**			
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**			

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)					
COUNTRY	SINGAPORE					
YEAR	2000					
	STEP 5					STEP 6
	G	H	I	J	K	L
ENERGY INDUSTRIES	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	0.00	58.41	0.99	57.83	212.03
Residual Fuel Oil	0	0.00	4,602.83	0.99	4,556.80	16,708.26
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		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	0.00	754.58	0.995	750.81	2,752.96
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						**19,673.24**
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**

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)					
COUNTRY	SINGAPORE					
YEAR	2000					
	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			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	191.51	43.33	8,298.13	20.2	167,622.19	167.622
Residual Fuel Oil	1,488.00	40.19	59,802.77	21.1	1,261,838.41	1,261.84
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	1,677.88	48.15	80,789.92	18.2	1,470,376.58	1,470.38
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	
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			**148,890.82**			
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**			

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)					
COUNTRY	SINGAPORE					
YEAR	2000					
	STEP 5					STEP 6
	G	H	I	J	K	L
MANUFACTURING INDUSTRIES AND CONSTRUCTION	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	0.00	167.62	0.99	165.95	608.47
Residual Fuel Oil	0	0.00	1,261.84	0.99	1,249.22	4,580.47
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		0.00	0.00		0.00	0.00
Petroleum Coke		0.00	0.00		0.00	0.00
Refinery Gas	0	0.00	1,470.38	0.99	1,455.67	5,337.47
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
Total						**10,526.41**
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**

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)					
COUNTRY	SINGAPORE					
YEAR	2000					
	STEP 1	STEP 2		STEP 3		
	A	B	C	D	E	F
TRANSPORT	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)
Domestic Aviation						
Gasoline			0.00		0.00	0.00
Jet Kerosene			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	677.90	44.8	30,369.92	18.9	573,991.49	573.99
Gas/Diesel Oil	1,113.55	43.33	48,250.88	20.2	974,651.58	974.65
			0.00		0.00	0.00
		Subtotal	**78,620.00**			
Rail Transport						
Gas/Diesel Oil			0.00		0.00	0.00
Residual Fuel Oil			0.00		0.00	0.00
Anthracite			0.00		0.00	0.00
Other Bituminous Coal			0.00		0.00	0.00
Coke Oven Coke			0.00		0.00	0.00
			0.00		0.00	0.00
		Subtotal	**0.00**			
National Navigation						
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			0.00		0.00	0.00
			0.00		0.00	0.00
			0.00		0.00	0.00
		Subtotal	**0.00**			
		Total Transport	**78,620.00**			
Memo items:						
Liquid Biomass			0.00		0.00	0.00
			0.00		0.00	0.00
		Total Biomass	**0.00**			

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)					
COUNTRY	SINGAPORE					
YEAR	2000					
			STEP 5			STEP 6
	G	H	I	J	K	L
TRANSPORT	**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])
Domestic Aviation						
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	573.99	0.99	568.25	2,083.59
Gas/Diesel Oil	0	0.00	974.65	0.99	964.91	3,537.99
		0.00	0.00		0.00	0.00
					Subtotal	**5,621.57**
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						
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	**5,621.57**
Memo items:						
Liquid Biomass		0.00	0.00		0.00	0.00
		0.00	0.00		0.00	0.00
					Total Biomass	**0.00**

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)					
COUNTRY	SINGAPORE					
YEAR	2000					
	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	41.38	47.31	1,957.73	17.2	33,672.96	33.67
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	852.80	3.6	3,070.08	15.2	46,665.22	46.67
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		**Total**	**5,027.81**			
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**			

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)					
COUNTRY	SINGAPORE					
YEAR	2000					
			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	0.00	33.67	0.99	33.34	122.23
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	46.67	0.99	46.20	169.39
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					**Total**	**291.63**
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**

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)					
COUNTRY	SINGAPORE					
YEAR	2000					
	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	81.62	47.31	3,861.42	17.2	66,416.40	66.42
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	510.30	3.6	1,837.08	15.2	27,923.62	27.92
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	5,698.50			
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			

MODULE	ENERGY					
SUBMODULE	CO_2 FROM FUEL COMBUSTION BY SOURCE CATEGORIES (TIER 1)					
COUNTRY	SINGAPORE					
YEAR	2000					
	STEP 5					STEP 6
	G	H	I	J	K	L
RESIDENTIAL 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
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	0.00	66.42	0.99	65.75	241.09
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	27.92	0.99	27.64	101.36
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					**Total**	**342.46**
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**

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