SINGAPORE'S THIRD NATIONAL COMMUNICATION AND FIRST BIENNIAL UPDATE REPORT

Under the United Nations Framework Convention on Climate Change

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National Climate Change Secretariat

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FOREWORD

Keeping Singapore Clean and Green

Singapore has placed high priority on maintaining a clean and green living environment since our independence in 1965. This brings health and quality of life benefits, and enhances Singapore's attractiveness to investments that grow our economy and provide good jobs.

Our small size (716km^2) and high population density (7,540 people per km^2) limit our ability to draw on alternative energy sources such as solar, wind or nuclear. However, we use natural gas - the cleanest form of fossil fuel – for 84% of our electricity generation, which is among the highest in the world. We price energy at market cost without any subsidy so that households and businesses use energy judiciously. We also aim to increase our solar deployment from around 15 megawatt-peak (MWp) today to 350MWp by 2020, as solar energy becomes more cost-effective.

Given Singapore's limited alternative energy options, energy efficiency is our key strategy to reduce carbon emissions. We encourage building owners and companies to adopt energy efficient building designs, equipment and processes by offering incentives and grants. The Energy Conservation Act mandates energy intensive users in the industrial and transport sectors to appoint at least one energy manager, monitor and report their energy use and greenhouse gas emissions, and to submit energy efficiency improvement plans on an annual basis.

Through these efforts, Singapore generates relatively low levels of carbon emissions per GDP dollar in the world, ranking 113th out of 140 countries.[1] Singapore's emissions grew at an average annual rate of 2.0% in the last decade, compared to 2.2% globally.[2] During this period, Singapore's GDP grew by 76%, compared to a 21% increase in emissions and a 34% increase in energy use. This reflects our improved energy and carbon efficiency. Over the same period, our carbon intensity decreased by 30% (or -3.6% per annum), which compares favorably with the global average decrease of 0.12% (or a 0.01% decrease per annum).[3]

[1] Source: IEA Key World Energy Statistics, 2014.
[2] Source: IPCC 5th Assessment Report, Working Group 3 Report.
[3] Source: IEA CO_2 Emissions From Fuel Combustion, 2013.

Even though Singapore only accounts for less than 0.2% of annual global carbon emissions, we will continue to do our part. We are taking measures to reduce emissions to 7-11% below our business-as-usual (BAU) level by 2020. If there is a legally binding global agreement on climate change, we will reduce our emissions to 16% below our BAU level by 2020.

Preparing for the Future

We are also studying ways to stabilise our emissions over the long term. This includes research, development and deployment of low-carbon technology and urban systems. We have allocated S$300 million through a National Innovation Challenge to fund research and development (R&D) to increase energy efficiency, reduce carbon emissions, and increase energy options. Our experiences and lessons learnt can be shared with other cities facing similar challenges. We are also well placed to serve as a "living laboratory" to test, pilot, and commercialise innovative solutions for Asia and the world.

As a small, low-lying city-state, Singapore is vulnerable to the consequences of climate change, such as rising sea levels, intense rainfall, dry spells and other extreme weather events. As such, adapting to the effects of climate change is a national priority. For example, since 2011, we have increased the minimum reclamation level by 1.0m for newly reclaimed land to cater for long-term sea level rise. We are enhancing drainage infrastructure and flood management systems. We have built a robust, diversified and sustainable water supply through a Four National Taps strategy: harnessing water from local catchment areas, imported water, reclaimed water known as NEWater[4] and desalinated water. This is complemented by policies and measures to promote water conservation.

[4] NEWater is high-grade reclaimed water by PUB, Singapore's national water agency. It is treated used water that has been purified using dual-membrane (via microfiltration and reverse osmosis) and disinfected using ultraviolet technologies.

Contributing to a Global Approach

International collaboration is essential to address climate change. Singapore participates actively in United Nations Framework Convention on Climate Change discussions to work towards a global agreement. We regularly organise technical cooperation programmes to share our experiences with officials from other developing countries to address climate change. Our Building and Construction Authority (BCA) has also collaborated with the United Nations Environment Programme (UNEP) to establish the BCA Centre for Sustainable Buildings – the first in Asia, and one of a few such centres in the world. The centre is currently working with UNEP to help other developing countries in Asia develop green building policies and actions.

The global challenge of climate change requires global action by all countries. Singapore has been committed to a clean, green and sustainable environment since independence 5 decades ago, and remains committed to working closely with all countries to address this global challenge together.

Mr Teo Chee Hean

Deputy Prime Minister
Chairman, Inter-Ministerial Committee on Climate Change
Republic of Singapore

NOTES ON USING THIS DOCUMENT

As a non-Annex I Party to the United Nations Framework Convention on Climate Change Convention (UNFCCC), Singapore is obliged to submit our National Communications (NC) every four years[5] and our 1st Biennial Update Report (BUR) to the UNFCCC in 2014[6].

Singapore submitted our 2nd NC in 2010. As the submission year for Singapore's 3rd NC coincides with the submission year of our 1st BUR, this document presents both Singapore's 3rd NC and 1st BUR.

The following chapters are common to both the NC and BUR. The narratives in the NC for these chapters serve as a summary of the detailed information presented in the corresponding chapters in the BUR.

- National Circumstances
- National Greenhouse Gas Inventory Report

  The BUR covers the inventory for the calendar year 2010; which is no more than four years prior to the date of the submission[7].
- Mitigation Measures

  The BUR presents Singapore's on-going and planned mitigation actions till 2020.

This document was prepared in accordance with:

- UNFCCC Guidelines for the Preparation of National Communications from non-Annex I Parties (decision 17/CP.8); and
- UNFCCC Biennial Update Reporting Guidelines for non-Annex I Parties (decision 2/CP.17 annex III).

[5] UNFCCC decision 1/CP.16
[6] UNFCCC decision 2/CP.17
[7] UNFCCC decision 2/CP.17

SINGAPORE'S THIRD NATIONAL COMMUNICATION

Under the United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

Singapore is a small island city-state with one of the highest population densities in the world. Given Singapore's small size and dense urban landscape, there are challenges to using alternative energy sources such as solar, nuclear and wind energy.

Being an alternative-energy disadvantaged country, there will be limits to the extent of emissions reductions that can be undertaken given the current state of technology. Such difficulties in switching to alternatives are recognised by the United Nations Framework Convention on Climate Change (UNFCCC).

Singapore's greenhouse gas emissions for 2010 totalled 46,831.68 gigagram CO_2-equivalent. Carbon dioxide (CO_2) accounted for 96.5% of total emissions. Non-CO_2 gases such as methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6) accounted for the remaining 3.5% of total emissions.

Singapore has pledged to reduce emissions by 16% below 2020 business-as-usual (BAU) levels if there is a legally binding global agreement in which all countries implement their commitments in good faith. Ahead of this, Singapore has embarked on policies and measures that will reduce our emissions by 7% to 11% below 2020 BAU levels.

A key pillar of Singapore's strategy to mitigate greenhouse gas emissions is to improve energy efficiency across different sectors of the economy. Singapore has moved towards a cleaner fuel mix for electricity generation, switching from fuel oil to natural gas which has lower carbon content per unit of electricity generated. While Singapore actively invests in research on clean energy technologies, there are limits to the deployment of alternative or renewable energy sources in Singapore.

In addition to reducing emissions, Singapore will continue to raise awareness and build capabilities to improve energy efficiency across the sectors through the use of incentives or regulatory measures where appropriate.

As a relatively low-lying, densely populated island in the tropics, Singapore is naturally vulnerable to the impacts of climate change. Singapore takes a proactive, long-term approach towards climate change adaptation. Climate change resilience goes beyond physical adaptation, and must include building resilient mindsets as well as collective action to safeguard our environment. Climate resilience and adaptation plans will be continuously reviewed and adjusted as new knowledge and information on the effects of climate change become available.

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 approach to climate change.

As a responsible member of the global community, Singapore is actively working at the international, regional and bilateral levels to support global efforts to address the challenges of climate change.

Third National Communication

Chapter 1
National Circumstances

Despite increased urbanisation, Singapore has developed into a clean and green city through decades of good planning.

1 NATIONAL CIRCUMSTANCES

Singapore's twin goals of growing our economy and protecting the environment remain central to our national strategy.

Although we contribute less than 0.2% of global emissions, we will continue to take steps to reduce our carbon emissions, building on past mitigation efforts. This will have to take into account our unique national circumstances as an island-state with limited access to renewable energy.

Country Circumstances and Constraints

Singapore is a small island state with a total land area (including that of smaller surrounding islands) of about 716 km^2. Much of the island is flat and relatively low-lying. As of 2013, Singapore's total population, including foreigners working in Singapore, is estimated to be 5.4 million. Singapore's population density of about 7,540 people per km^2 is one of the highest in the world.

Given our small size and dense urban landscape, there are challenges to using alternative energy sources such as solar and nuclear. Singapore's geographical features also limit our access to geothermal resources, hydroelectricity, wind, tidal and wave power.

Being a small, alternative-energy disadvantaged city-state, there will be limits to the extent of emissions reductions that can be undertaken given the current state of technology. Such difficulties in switching to alternatives are recognised by the United Nations Framework Convention on Climate Change (UNFCCC).[8]

In addition, while Singapore is a non-Annex I Party under the UNFCCC, our efforts on climate change are fully funded domestically.

[8] Articles 4.8 and 4.10 of the UNFCCC take into consideration national circumstances of developing countries - especially small island countries, countries with low-lying coastal areas, land-locked and transit countries, and countries disadvantaged in the use of alternative energy sources, amongst others. Article 4.10 recognises the circumstances of such countries with "serious difficulties in switching to alternatives."

Solar panels at the National Environment Agency's Centre for Climate Research Singapore.

Institutional Arrangements

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 approach to climate change. Chaired by the Deputy Prime Minister, Coordinating Minister for National Security and Minister for Home Affairs, the IMCCC 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.

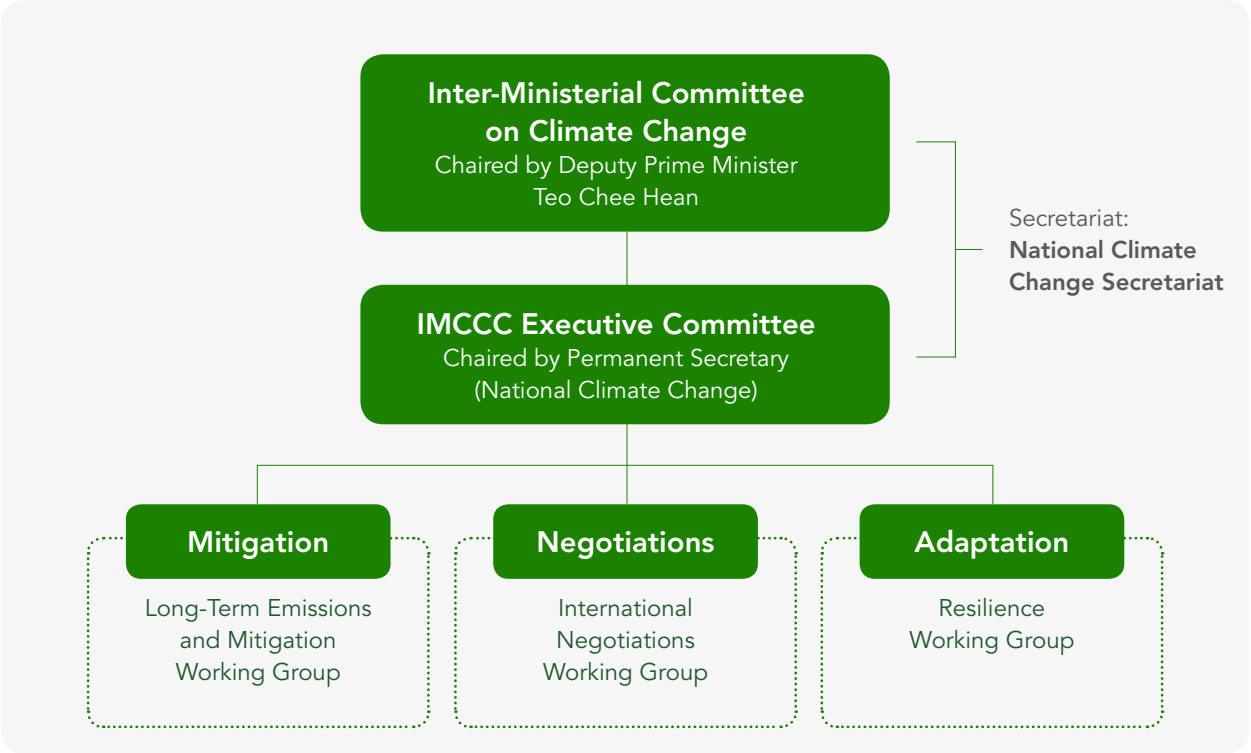
The IMCCC is supported by an Executive Committee (Exco) which oversees the work of three working groups:

a) the International Negotiations Working Group develops Singapore's international climate change negotiations strategy under the UNFCCC;

b) the Long Term Emissions and Mitigation Working Group studies how Singapore can stabilise our long-term emissions; and

c) the Resilience Working Group studies Singapore's vulnerability to the effects of climate change and recommends long-term plans that ensure the nation's adaptation to future environmental changes.

In July 2010, the National Climate Change Secretariat (NCCS) was established as a dedicated unit under the Prime Minister's Office to ensure the effective coordination of Singapore's domestic and international policies, plans and actions on climate change.



National Climate Change Strategy

In June 2012, the Singapore Government released the National Climate Change Strategy (NCCS-2012) document, which outlines Singapore's plans to address climate change through a whole-of-nation approach. Entitled 'Climate Change and Singapore: Challenges. Opportunities. Partnerships.', the document reflects the key elements of Singapore's climate strategy. They include reducing emissions across sectors, building capabilities to adapt to the impact of climate change, harnessing green growth opportunities as well as forging partnerships on climate change action.

Education, Training and Public Awareness

People, private and public (3P) partnerships are key in our efforts to address climate change. We encourage close partnerships between the public sector agencies, leaders from the business sector, academia, the media, non-governmental organisations (NGOs) and community groups to foster awareness and action on climate change-related issues.

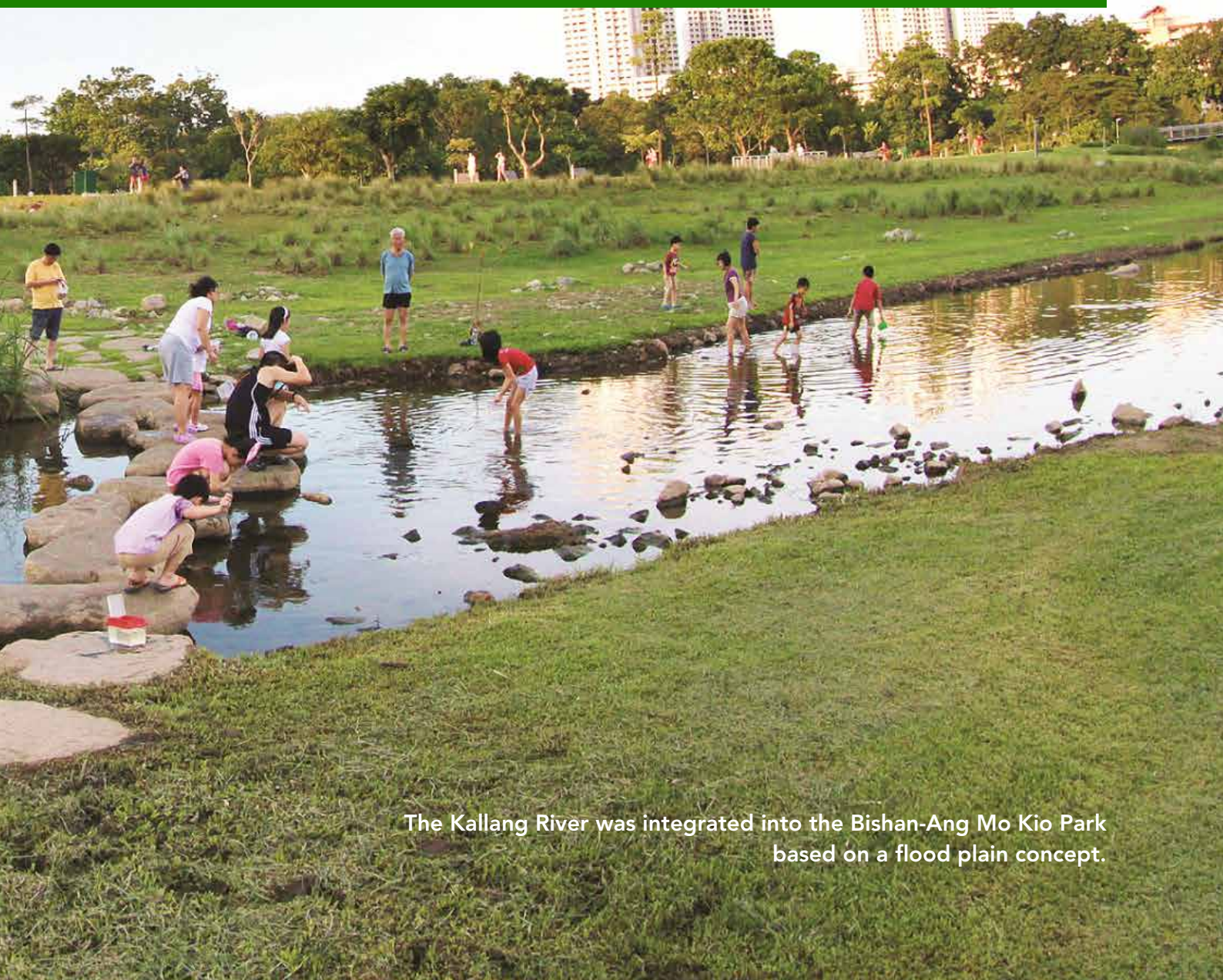
Policies and initiatives to address climate change are supported by public outreach and education programmes to raise awareness and engender action. Climate change topics are also featured in the school curriculum, in subjects such as the GCE 'A' Levels General Paper, Economics, Geography and the sciences. A drama skit for primary schools was recently launched to explain the cause and effect of climate change, as well as to equip students with practical tips on what they can do at home and in school to address climate change. Within the community, the annual flagship Clean and Green Singapore campaign organised by the National Environment Agency (NEA) encourages Singaporeans to care for and protect the environment by adopting environmentally-friendly lifestyles. National programmes such as energy labelling and fuel economy schemes empower consumers to make informed purchasing decisions based on the energy-efficiency of household appliances and motor vehicles.

More information on Singapore's national circumstances, including information on features of Singapore's geography, climate and economy, is presented in Chapter 1 of the Biennial Update Report (BUR).

Clean & Green Singapore 2014.

Third National Communication

Chapter 2
National Greenhouse Gas Inventory Report



The Kallang River was integrated into the Bishan-Ang Mo Kio Park based on a flood plain concept.

2 NATIONAL GREENHOUSE GAS INVENTORY REPORT

The most significant greenhouse gas emitted in Singapore is carbon dioxide, primarily produced from the burning of fossil fuels to generate energy used by the industry, building, household and transport sectors. The main contributor to greenhouse gas emissions (29.0%) is the combustion of natural gas to generate electricity.

Singapore's emissions for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) were estimated using the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories and based on the Sectoral approach. The Tier 1 methodology was used for most emission estimates. The emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) from integrated circuit and semiconductor production were estimated using the Tier 2 methodology from the 2006 IPCC Guidelines.

Singapore's Greenhouse Gas Emissions in 2010

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.

Greenhouse Gas	Emissions (Gg CO_2e)	Percentage of Total Emissions
CO_2	45,203	96.5%
PFCs	988	2.1%
N_2O	401	0.9%
CH_4	114	0.2%
SF_6	86	0.2%
HFCs	40	0.1%

The compilation of the greenhouse gas inventory is coordinated by the National Environment Agency with data from other agencies and companies. Quality control checks for the computation of greenhouse gas emissions were developed based on the 2000 IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories to improve the transparency, consistency, comparability, completeness and accuracy of the inventory. The multi-agency greenhouse gas inventory team uses a four-stage inventory preparation process to facilitate continuous improvement to the national greenhouse gas inventory for subsequent inventory compilation cycles.

More information on the National Greenhouse Gas Inventory is presented in Chapter 2 of the Biennial Update Report (BUR).

HDB's first eco-precinct, Treelodge@Punggol, features solar panels to power common area lighting and lifts, roof-top greenery, dedicated recycling chutes and a system to collect rainwater.

Third National Communication

Chapter 3
Mitigation Measures

3 MITIGATION MEASURES

Singapore has pledged to reduce emissions by 16% below 2020 business-as-usual[9] (BAU) levels if there is a legally binding global agreement in which all countries implement their commitments in good faith. Ahead of this, Singapore has embarked on policies and measures that will reduce our emissions by 7% to 11% below 2020 BAU levels.

Singapore's Approach to Reducing Emissions

Energy is a strategic resource for Singapore as we are almost completely reliant on imports of oil and gas for our energy needs. Recognising that energy is a scarce resource, Singapore prices fuel and electricity according to market supply and demand. We do not subsidise energy costs. By pricing energy correctly, we incentivise firms and households to make appropriate energy consumption choices. This minimises energy wastage and over-consumption, which contributes to reducing emissions.

Singapore has also moved towards a cleaner fuel mix for electricity generation, switching from fuel oil to natural gas, which has lower carbon content per unit of electricity generated. However, there are limits to how much more emissions we can reduce by switching fuels, since natural gas already constitutes 84% of our fuel mix for electricity generation in 2012. While we continue to invest actively in research on clean energy technologies since the most direct way to reduce emissions is to cut down the use of fossil fuels, there are limits to the deployment of alternative or renewable energy sources in Singapore.

Given Singapore's limited access to renewable energy, energy efficiency is one of our core carbon emissions mitigation strategies. This will require our households and businesses to be more energy conscious and make adjustments to their daily activities, choices and processes.

[9] Projecting from 2005, Singapore's BAU emissions are expected to reach 77.2 million tonnes (MT) in 2020.

As an open economy without natural resources, we need to reduce carbon emissions in a cost-effective way. Hence, the Government has identified the following areas as part of a comprehensive strategy to promote energy efficiency in Singapore.

- Promoting adoption of energy efficient measures and technologies by addressing market barriers to energy efficiency.

- Building capability to sustain and drive energy efficiency efforts and to develop the local knowledge base and expertise in energy management.

- Raising awareness by reaching out to the public and businesses so as to promote energy efficient behaviour and practices.

- Supporting research and development to enhance Singapore's capability in energy efficient technologies.

We will continue to push ahead with mitigation efforts in the different sectors. For example, under the building sector, we are working towards 80% of our building stock to be certified as green buildings by 2030. For the transport sector, we already have one of the most stringent and innovative systems in the world for controlling vehicle demand and usage, through a vehicular quota and road pricing system. A Carbon Emissions-based Vehicle Scheme was introduced in 2013 to encourage car buyers to purchase low-emissions cars. To encourage the use of public transport, the length of the rail network in Singapore will be doubled from 178km in 2012 to about 360km by 2030.

More information on Singapore's mitigation measures are presented in Chapter 3 of the Biennial Update Report (BUR).

Built across the mouth of the Marina Channel, the Marina Barrage creates Singapore's 15th reservoir, and the first in the heart of the city.

Third National Communication

Chapter 4
Vulnerability and Adaptation Measures

4 VULNERABILITY AND ADAPTATION MEASURES

As a small, low-lying island city state of 716 km^2 situated in the tropics, Singapore is naturally vulnerable to the impacts of climate change. With a population of 5.4 million, Singapore is also one of the most densely populated countries in the world. Given these circumstances, it is important for Singapore to prepare for and adapt early to climate change.

Effects of Climate Change

The Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5) concluded that the global climate is undergoing significant change. Global temperatures are projected to rise by 0.3 – 4.8°C by 2100 over present levels, while global mean sea levels are expected to increase by 0.26 – 0.82m over the same period, based on future scenarios[10] representative of greenhouse gas concentrations. Extreme precipitation events over the region are also projected to be more intense and more frequent.

In order to translate the IPCC's findings to Singapore's context to prepare and plan for adaptation measures, Singapore conducted the 1st National Climate Change Study (2007 – 2013), which made use of data and scenarios from the Fourth Assessment Report (AR4), to examine the long term effects of climate change on Singapore. The study found that the mean sea level around Singapore could rise by up to 0.65m[11], and temperatures could increase by up to 4.2°C in 2100. These findings from the study, completed in 2009, are generally consistent with the projections from AR4 and AR5, and are summarised in the table overleaf.

[10] The scenarios used to derive IPCC AR5 projections are based on greenhouse gas concentration pathways that are compatible with the range of emissions available in the current scientific literature, and include mitigation policies. They differ from the emission scenarios used in IPCC AR4, which were based on alternative socio-economic futures incorporating a range of different assumptions regarding population, economic growth, technological innovation and attitudes to social and environmental sustainability.

[11] Not inclusive of ice sheet melt, estimated at the time of AR4 to be in the region of 0.2m

Climate Change Projections (in 2100 relative to present)[12]	Singapore's 1st National Climate Change Study Local Findings	IPCC AR4 Projections	IPCC AR5 Projections
Change in Average Temperature (°C)	+2.7 to +4.2 (A1B Scenario)	+1.7 to + 4.4 (A1B Scenario, Global)	+0.3 to +4.8 (All Scenarios, Global)
Change in Mean Sea Level (m)	+0.24 to +0.65 (B1, A1B, A2 Scenarios)	+0.18 to +0.59 (All Scenarios, Global)	+0.26 to +0.82[13] (All Scenarios, Global)

Our National Climate Change Study findings will be continually updated as climate science and models improve. For example, the models used in AR5, as compared to AR4, have increased in number and generally have better spatial resolution, which contributes to an improved treatment of the climate processes. Some models also include new interactive 'Earth System' processes, such as carbon cycle feedback and are able to project the future climate more realistically.

Building Climate Science Capabilities

Adaptation planning benefits significantly from robust scientific analysis of climate change effects and impact. While the IPCC Assessment Reports provide valuable information to lay the scientific foundation for Singapore's adaptation planning, it is necessary for Singapore to supplement this with studies that translate these findings into Singapore's context through further modeling and a deep understanding of climate science.

Therefore, in March 2013, the Meteorological Service Singapore (MSS) established the Centre for Climate Research Singapore (CCRS) to strengthen in-house capability in climate science and climate modelling. Guided by an International Scientific Advisory Panel, chaired by Professor Lim Hock, Director of Research Governance and Enablement at the Office of the Deputy President (Research and Technology), National University of Singapore (NUS)[14], the CCRS will also tap on relevant expertise and institutions through its Climate Science Experts Network to coordinate and steer climate-related research in Singapore. This will augment our national preparedness for climate change and help policy makers make informed decisions, enabling us to make early preparations to address the potential impacts of climate change in Singapore.

[12] Studies to assess future change in rainfall for Singapore are ongoing.
[13] Ice sheet melt processes have been better quantified in AR5.
[14] Other members of the panel include Prof Chang Chih-Pei, Prof Sir Brian Hoskins, Prof Lord Julian Hunt, Dr Akio Kitoh, Prof Kerry Sieh and Prof John Zillman.

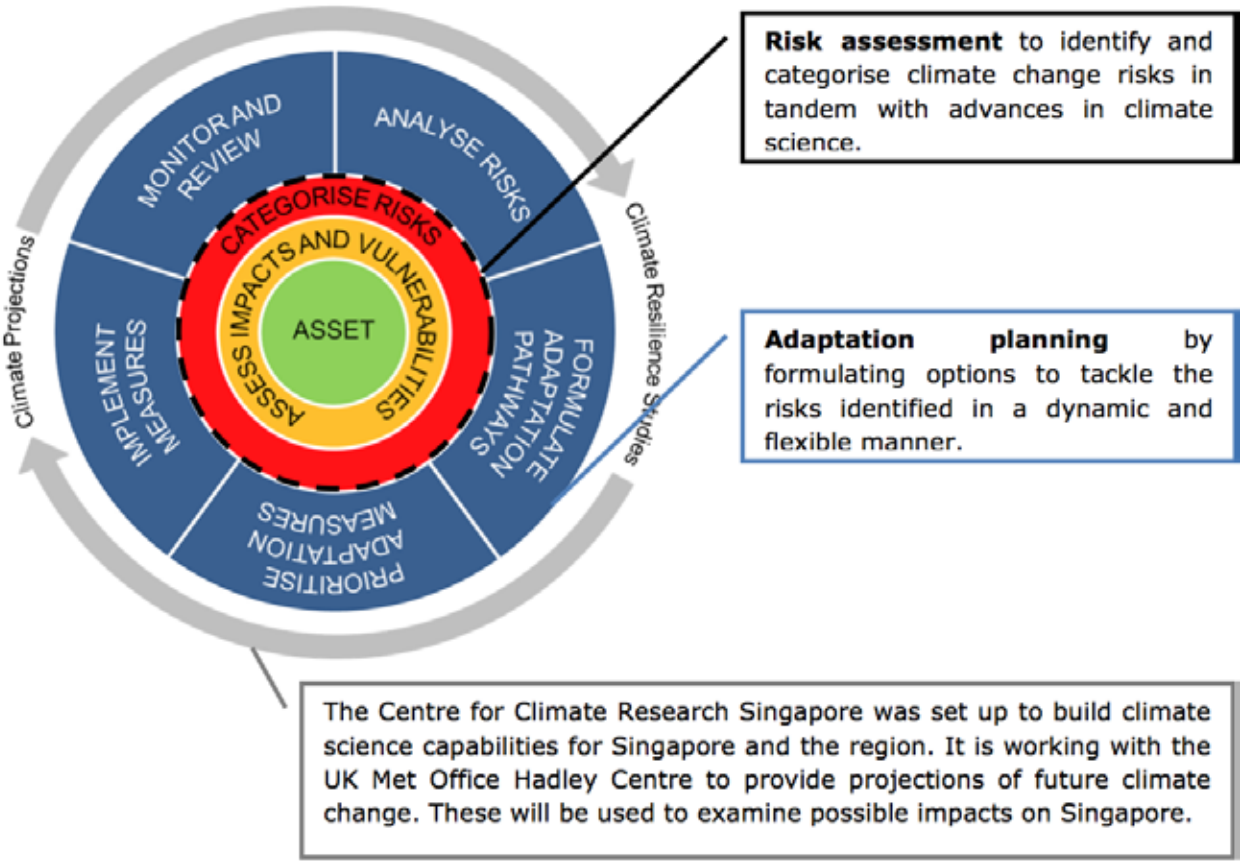
Official opening of the Centre for Climate Research Singapore in March 2013.

Preparing Singapore for Possible Climate Change Impacts

Even with international efforts to limit the rise in global temperatures, there is a need for Singapore to tackle climate risks as early as possible to maximise the benefits and reduce the economic costs of adaptation. Some adaptation measures will require time to implement, and have to be taken early. Adaptation plans must also be designed for flexibility so as to incorporate new climate data and science as and when they arise.

To coordinate such efforts, a multi-agency Resilience Working Group (RWG), led by the Ministry of the Environment and Water Resources (MEWR) and the Ministry of National Development (MND), was set up in 2010 under the auspices of the Inter-Ministerial Committee on Climate Change (IMCCC). The RWG aims to assess Singapore's physical vulnerabilities to climate change based on a Resilience Framework developed to guide the formulation of adaptation plans to safeguard Singapore against potential climate change impacts up to the year 2100 (see below for Singapore's Resilience Framework).

Singapore's Resilience Framework



The agencies in this Working Group include the Ministry of Health (MOH), the Ministry of Finance (MOF), the Building and Construction Authority (BCA), the Civil Aviation Authority of Singapore (CAAS), the Energy Market Authority (EMA), the Housing and Development Board (HDB), the Infocomm Development Authority of Singapore (IDA), JTC Corporation, the Land Transport Authority (LTA), the Maritime and Port Authority of Singapore (MPA), the National Climate Change Secretariat (NCCS), the National Parks Board (NParks), the National Environment Agency (NEA), PUB, Singapore's national water agency, the Singapore Land Authority (SLA) and the Urban Redevelopment Authority (URA). Through this inter-agency effort, Singapore's adaptation plans are being coordinated to derive upstream and downstream synergies and to optimise available resources. Such an integrated process is especially important when there are interdependencies in the system. For example, infrastructure and the emergency services are dependent on the power grid for electricity and the telecommunications system. Therefore, there are knock-on and compounding effects should any of these latter systems fail.

The outcomes and findings from the 1st National Climate Change Study served as inputs to help shape and refine our resilience plans, and also to inform planners in the scoping of further studies to address information gaps for greater robustness. We outline some of the preliminary plans below.

a) Protecting our Coast

Much of Singapore's land area is low-lying. Efforts to enhance resilience against coastal erosion and inundation associated with rising sea levels coupled with short-lived, extreme meteorological events are already underway. For instance, the minimum reclamation levels for newly reclaimed land have been raised by 1m since 2011 to cater for long-term sea level rise.

BCA has commissioned a Risk Map Study (RMS) to better identify the specific coastal areas at risk of inundation and the potential damage associated. The results will complement the Coastal Adaptation Study (CAS) which commenced in October 2013, to develop long-term coastal protection strategies for Singapore.

b) Addressing Flood Risks

An increase in the intensity and frequency of extreme rainfall events in the future presents significant challenges. In fact, the total maximum hourly rainfall over Singapore was observed to have increased from an average of 96mm in 1980 to 117mm in 2012.

In view of greater weather uncertainties and urbanisation, PUB, Singapore's national water agency, has revamped its stormwater management approach to enhance flood protection for Singapore. PUB's strategy is to optimise the management of stormwater using a holistic source-pathway-receptor approach. This source-pathway-receptor approach looks at catchment-wide solutions to achieve higher drainage and flood protection standards. It covers the entire drainage system, addressing not just the pathway over which the stormwater travels (i.e. "Pathway" solutions such as drain widening and deepening), but also controlling rainwater at where it falls onto the ground (i.e. "Source" solutions such as on-site detention) and the areas where floods may occur (i.e. "Receptor" solutions such as specification of platform levels).

Steps have already been taken to mitigate flood risks. Over the last 30 years, we have reduced flood prone areas from about 32km² in the 1970s to about 0.49 km² as at January 2012. Under PUB's Code of Practice of Surface Water Drainage (COP), the minimum platform level for developments has been raised to further safeguard against the longer-term effects of higher sea level and rainfall intensity. In 2011, PUB also raised design standards for new drains to cater for more intense extreme rainfall events. Depending on the size of the catchment, this could vary from between 15% and 50% increase in drainage capacity.

With effect from 1 January 2014, developers/owners of land size 0.2 hectares or more are required under PUB's COP to implement measures to slow down surface runoff and reduce the peak flow of stormwater into the public drainage system by implementing on-site detention measures such as green roofs, rain gardens, and detention tanks.

c) Managing our Water Resources

Water resource management is also another key priority. An increase in weather variability may bring more frequent or more severe droughts that threaten the reliability of our water supply. To ensure a sustainable water supply for Singapore's population and industry, PUB has built a robust and diversified water supply for Singapore through the "Four National Taps", namely, local catchment water, imported water, NEWater[15] and desalinated water. In particular, NEWater and desalinated water are less dependent on rainfall and are thus more resilient against dry weather. By 2060, PUB plans to increase the current NEWater and desalination capacities so that NEWater and desalinated water meet up to 55% and 25% of our future water demand respectively.

d) Safeguarding our Biodiversity and Greenery

Past fragmentation of Singapore's forest makes them vulnerable to future long-term changes such as increased likelihood or duration of drought and higher average temperatures. Roadside trees could be uprooted in gusty storms, causing inconvenience and potential hazards to commuters. Wetlands may be affected by rainfall changes, sea level rise or water quality changes related to warming and changes in precipitation.

Sea level rise, in particular, will be a challenge for mangroves, which cannot retreat inland. Corals, which require sunlight, may not be able to grow upwards quickly enough to keep pace with rising sea levels. In addition, a 1 – 2°C rise in sea water temperatures will lead to coral bleaching.

To safeguard Singapore's biodiversity against the potential impacts of climate change, NParks is working with partner agencies and the community to protect existing species, increase connectivity of various green areas across our island, and enhance the resilience of ecosystems. This includes measures to restore forest and mangrove areas, diversify plant species, intensify planting, and increase connectivity between green areas. To keep our city green, tree management and maintenance is also being enhanced. NParks will continue to plan for and provide parks and green spaces island-wide as part of the national effort to lower ambient temperatures.

[15] NEWater is high-grade reclaimed water, produced from treated used water that is further purified using advanced membrane technologies, and ultra-violet disinfection, making it clean and safe to drink.

Sungei Buloh Wetland Reserve.

e) Strengthening Resilience in Public Health

Dengue is 'endemic' to Singapore and the region. The transmission of dengue is influenced by several factors, including the population of the disease vector, i.e. *Aedes* mosquitoes, and herd immunity against the disease in the population. Although higher mean temperature and absolute humidity could result in higher dengue incidence, other factors, such as urbanisation and population increases, contribute significantly to dengue transmission. NEA is collaborating with MOH to study the relationship between climatic factors – such as temperature, humidity and rainfall – and public health risks such as dengue fever.

To minimise dengue incidence through suppressing the mosquito vector population, NEA has put in place a nation-wide integrated programme, which entails mosquito, virus and human surveillance as well as public education and participation, law enforcement and research. NEA's Environmental Health Institute (EHI) is also leveraging on its research capability in vector-borne diseases to support efforts to strengthen Singapore's public health resilience to climate change.

A researcher at the National Environment Agency's Environmental Health Institute, investigating the behaviour of the Aedes mosquito and dengue virus so as to formulate appropriate preventive and control strategies.

Rising temperatures and reduced rainfall also affect the severity of smoke haze events. Smoke haze from land and forest fires in neighbouring countries is carried to Singapore by the prevailing wind. This creates health problems for all in the region, impacting the economy, tourism and the aviation industry. Singapore views the issue of trans-boundary haze very seriously. Together with MOH, NEA coordinates measures for haze-related illnesses through the National Haze Task Force.

f) Creating a Cooler Built Environment

An increase in outdoor air temperature from climate change could adversely affect thermal comfort. Urban morphology factors, such as greenery, building height and density, were found to strongly influence temperature at both the estate and building levels. Use of cool materials, paints and glazing can also reduce heat gain by buildings. URA is working together with HDB, JTC Corporation, BCA, NParks and NEA to better understand the effects of rising temperature in a highly urbanised environment like Singapore's, and will work towards identifying possible measures to ameliorate these effects.

Future Plans

Singapore takes a proactive, long-term approach towards climate change adaptation. Our plans will be continuously reviewed and adjusted as new knowledge and information on the effects of climate change become available. With the release of IPCC AR5, it is necessary to leverage on global and regional-level findings and investigate them at country/city level, to update our knowledge and resilience plans. This will be carried out in Singapore's 2nd National Climate Change Study. Work is ongoing at CCRS, in collaboration with the UK Met Office Hadley Centre for Climate Prediction and Research, to project climate parameters in greater detail. This will help us better understand the local impacts of climate change and the results will eventually strengthen Singapore's climate resilience and adaptation plans.

Climate change resilience goes beyond physical adaptation, and must include building resilient mindsets as well as collective action to safeguard our environment. The private sector will need to review their business continuity plans to cater for short-term disruptions caused by extreme weather events. Our people need to be mentally prepared for a changing environment.

Signing ceremony of Memorandum of Understanding between the National Environment Agency and UK Met Office to build up Singapore's capabilities in climate science, held in Singapore in May 2011.

Deputy Prime Minister Teo Chee Hean (centre) with the Lee Kuan Yew Water Prize 2012 recipient Professor Mark van Loosdrecht from the Delft University of Technology in the Netherlands (left), and the Lee Kuan Yew World City Prize 2012 recipient Mr Adrian Benepe, Commissioner of Parks and Recreation for New York City (right).

Minister for the Environment and Water Resources, Mr Vivian Balakrishnan, Ambassador Burhan Gafoor, and ADP Co-Chairs Mr. Kishan Kumarsingh and Mr. Artur Runge-Metzger at the UN Framework Convention on Climate Change meeting.

Trainers and participants at the "Capacity Building for SIDS Climate Change Negotiators" course held in Singapore in April 2014 in partnership with 'UNDP Barbados and OECS' and Australia.

Third National Communication

Chapter 5
International Cooperation

Mr Choi Shing Kwok, Permanent Secretary of the Ministry of the Environment and Water Resources (1st from right), and Mr Ronnie Tay, CEO of the National Environment Agency (1st from left), with H.E. Antony Phillipson, British High Commissioner to Singapore (2nd from right), and H.E. Dr Ryutaro Yatsu, Vice-Minister of the Ministry of the Environment, Japan (2nd from left), at the Green Growth and Business Forum 2014.

5 INTERNATIONAL COOPERATION

Climate change is a global challenge that requires a global solution. 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. As a responsible member of the global community, Singapore is actively working at the international, regional and bilateral levels to support global efforts in addressing the challenges of climate change.

International Cooperation

At the multilateral level, the United Nations Framework Convention on Climate Change (UNFCCC) provides the basis for governments to cooperate in finding a global response to climate change. Singapore is committed to supporting a multilateral rules-based system as embodied by the UNFCCC. Singapore ratified the UNFCCC in 1997 and acceded to the Kyoto Protocol in 2006. Although our emissions are only 0.2% of global emissions, we have pledged in 2009 to reduce our greenhouse gas emissions by 7-11% below business-as-usual (BAU) levels in 2020 and to further reduce our emissions by 16% if there is a legally binding global agreement. Singapore actively participates in the on-going negotiations on a new 2015 global agreement. Singapore has also co-hosted workshops in Singapore with the UNFCCC Secretariat on the preparation, submission and implementation of nationally appropriate mitigation actions and the Secretariat of the Convention on Biological Diversity (CBD) on building capacities in developing countries on REDD+.

As part of our support for a holistic multilateral response to climate change, Singapore has also participated in and contributed experts to the working groups convened by the International Maritime Organisation (IMO), the International Civil Aviation Organisation (ICAO) and the World Trade Organisation (WTO) to help develop measures in their respective sectors to respond to climate change. At the WTO, Singapore has joined 13 countries to explore opportunities to reduce tariffs, building upon the Asia-Pacific Economic Cooperation (APEC) list of Environmental Goods by end 2015. At the IMO, Singapore supported the IMO's adoption of mandatory ship energy

efficiency measures that include an Energy Efficiency Design Index (EEDI) and a Ship Energy Efficiency Management Plan (SEEMP) to reduce emissions from new and existing ships, which came into force on 1 January 2013. Singapore has also participated in and contributed experts to the working groups, committees and task forces in ICAO on global emissions aspirational goals, state action plans, technological and operational measures, sustainable alternative fuels for aviation, assistance to states and market-based measures.

We have also engaged and collaborated with other specialised UN agencies on specific initiatives and programmes to address climate change. For example, the Building and Construction Authority (BCA) of Singapore has been working closely with the UN Environment Programme Sustainable Building and Climate Initiative (UNEP-SBCI) to promote standards for sustainable buildings in the region. The UNEP-SBCI initiative is aimed at lowering emissions in the buildings sector and contributes to lowering emissions at the global level while helping other developing countries meet their development needs.

Promoting Standards for Environmentally Friendly Buildings

The Green Mark (GM) certification programme was initiated by BCA in 2005 to encourage the design and construction of more environmentally friendly buildings. Since then, GM has become one of the benchmarks for sustainable building practices in Southeast Asia and beyond. As at 2013, more than 200 applications for GM certification have been received from more than 70 cities from 15 countries.

In recognition of Singapore's leadership in promoting green building policies and sustainable built environments, BCA has been accorded several international awards :-

i. The Aspen Institute Energy and Environment Award (Government) – 2010;
ii. The World Green Building Council Government Leadership Award (Regional Leadership) – 2011; and
iii. The International (I-Star) Energy Efficiency Award – 2013.

BCA has worked closely with UNEP on various initiatives. From 2010 to 2012, BCA served as an elected member of the UNEP-SBCI advisory board and worked on outreach projects such as the production of Southeast Asia country reports on green building development and initiatives in the region. In 2011, BCA signed an MOU with UNEP to formally establish the BCA Centre for Sustainable Buildings (BCA CSB) as a 'centre collaborating with UNEP'. At present, BCA is serving as a member of UNEP's Sustainable Building Index Steering Committee.

BCA is also working with UNEP and other partners to develop Nationally Appropriate Mitigation Actions (NAMAs) for the building sector in Asia, focusing on four countries in Southeast Asia – Indonesia, Philippines, Thailand and Vietnam. The project is part of the International Climate Initiative (ICI) supported by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Regional Cooperation

Singapore supports the APEC-wide aspirational goals of reducing energy intensity of 45% from 2005 levels by 2035 and increasing forest cover by at least 20 million hectares by 2020. To guard against unsustainable deforestation that would lead to an increase in greenhouse gases and transboundary haze pollution, Singapore has initiated the establishment of the Association of Southeast Asian Nations Regional Haze Training Network (ASEAN RHTN). We have also committed to implementing the ASEAN Action Plan on Joint Response to Climate Change (AAP-JRCC). It was finalised in 2012, and aimed at enhancing information sharing, capacity building and technology transfer within the region and beyond.

As a small city-state, Singapore faces common challenges with other cities in adapting to climate change. To share our experience and facilitate discussions in these issues, Singapore has initiated and hosted the World Cities Summit (WCS), Clean Enviro Summit as well as the Singapore International Water Week (SIWW). These events are part of our efforts to bring policy makers and stakeholders in city planning and water management together to examine urban challenges, identify shared solutions and share best practices on *inter alia* sustainable urban planning, water and waste management as well as climate resilience.

Singapore also actively participates in the C40 Cities Climate Leadership Group (C40). The C40 is a network of 69 cities committed to addressing climate change globally by implementing sustainable climate related actions locally. Our involvement in the C40 allows us to share our experience on sustainable development, and learn from the best practices of other major cities. We established the Centre for Climate Research Singapore (CCRS) in 2013 to strengthen capabilities in climate science and to foster research partnerships at the national, regional and broader international level. Singapore's National Research Foundation (NRF) has also provided significant funding to establish research centres of excellence in Singapore in partnership with MIT, ETH Zurich, Peking University, and other renowned universities, working on urban mobility, environmental sensing and modelling, and low carbon research, amongst others. We will continue to collaborate with other countries to promote green growth and best practices in sustainable development.

Water Leaders Summit during the Singapore International Water Week.

Bilateral Cooperation

At the bilateral level, Singapore has provided technical assistance and capacity building programmes to officials from many developing countries since 1992 on various climate-related issues. These programmes are held under the auspices of the Singapore Cooperation Programme (SCP). To date, over 7,000 participants from more than 150 developing countries have attended SCP training courses on topics such as sustainable urban development, water management and energy efficiency and emissions reduction.

Recognising the growing importance in addressing climate change, Singapore established a dedicated programme on Sustainable Development and Climate Change (SDCC) under the SCP in 2012. The new SDCC Programme is tailored to meet the needs of our partners, in particular the Small Island Developing States (SIDS) and the Least Developed Countries (LDCs). The new programme is aimed at sharing our experiences on adopting sustainable solutions for cities and building resilience to climate change. Where possible, the SDCC programme also involves collaborations with developed country partners so as to pool expertise and resources. This allows us to deliver more impactful and relevant programmes. For example, Singapore has partnered Germany (Deutsche Gesellschaft für Internationale Zusammenarbeit) and Australia, to host workshops on climate finance and a climate change negotiators' course in Singapore as part of our joint efforts to help build capacities in developing countries, particularly SIDS.

Regional Workshop on Scaling up Climate Finance in the Asia Pacific

SCP, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ} and the Lee Kuan Yew School of Public Policy, with the support of the Climate Development Knowledge Network (CDKN) organised a Regional Workshop on Scaling up Climate Finance in the Asia Pacific from 22 to 24 April 2013 in Singapore.

The Workshop focused on a broad range of issues including climate finance fundamentals, international and regional challenges, readiness for climate finance and mobilising private investments among others. The Workshop was attended by 22 participants (including representatives from Ministries of Environment, Finance, Planning and Investment; international organisations; multilateral development banks and private sector) from 9 different countries. A follow up workshop on mobilising private funds for climate finance was conducted in Singapore from 20 to 21 March 2014.

Bilateral Cooperation – Regional workshop on scaling up Climate Finance in the Asia Pacific.

Highlights of Sustainable Development and Climate Change (SDCC) Programme

No.	Course Name	Partnerships	Course dates/duration	No. of participants	Course Description
1	2nd Asia Pacific Dialogue on Climate Finance and the Green Climate Fund	Asian Development Bank; Government of Japan; Government of Australia; World Resources Institute (WRI) and Climate Analytics (CA).	2-day dialogue in Singapore in March 2013	32	The dialogue covered issues including climate finance readiness, operationalization of the Green Climate Fund (GCF) and mobilisation of private sector capital among others.
2	Climate Change, Energy and Environment	Initiative for ASEAN Integration (IAI)	Four in-country training courses over one week, conducted between July 2012 and March 2013	101	The training programme provided conceptual and practical knowledge for the evaluation and management of climate change issues. The programme dealt with the complex nature of climate change-related challenges and budgeting frameworks.
3	Scaling up Climate Finance in the Asia Pacific	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	3-day training course in Singapore in April 2013	22	The Workshop focussed on a broad range of issues including climate finance fundamentals, international and regional challenges, readiness for climate finance and mobilising private investments among others.
4	Climate Change Adaptation Strategy	SCP Training Awards / Small Island Developing States Technical Cooperation Programme	One-week training course in Singapore in June 2013	15	The course shared with participants Singapore's policies and regulatory frameworks for the development and management of climate change adaptation strategies.
5	UNFCCC Workshop on Nationally Appropriate Mitigation Actions (NAMAs)	UNFCCC Secretariat	3-day workshop in Singapore in August 2013	85	The workshop served as a platform to share operational knowledge, best-practices and successes in the preparation, submission and implementation of NAMAs.
6	Climate Change Adaptation Strategy for Small Island Developing States	Japan-Singapore Partnership Programme for the 21st Century (JSPP21)	One-week training course in Singapore in September 2013	35	The course enabled participants to gain an appreciation of Singapore's and Japan's experiences in sustainable development and climate change, with a focus on the adaptation strategies and measures aimed at addressing the challenges and impacts of climate change.
7	Sustainable Water Resources Management	SCP Training Awards / Small Island Developing States Technical Cooperation Programme	2-week training course in Singapore in October 2013	23	The course provided an understanding of Singapore's water and used water policies, including the management of drainage, potable water, and used water systems. Participants were also encouraged to share experiences from their own countries.

No.	Course Name	Partnership	Course dates/duration	No. of participants	Course Description
8	Advanced Course on Sustainable Town Planning and Transport Management	Initiative for ASEAN Integration (IAI)	Two in-country training courses over one week in January 2014	40	This course provided a platform for participants to gain a comprehensive understanding on Singapore's policies and implementation mechanisms in sustainable town planning and transport management.
9	City Executive Leaders Programme (EXCEL)	SCP Training Awards / Small Island Developing States Technical Cooperation Programme	One-week training course in Singapore in January 2014	28	The course encouraged the application of high-density, high liveability guiding principles in urban development and management based on Singapore's experience.
10	3rd Asia Pacific Dialogue on Climate Finance and Green Climate Fund	Asian Development Bank and Government of Japan	2-day dialogue in Singapore in February 2014	85	The dialogue covered issues including climate finance readiness, operationalisation of the Green Climate Fund (GCF) and mobilisation of private sector capital among others.
11	Cities and Climate Change	Singapore-Cities Development Initiative for Asia Third Country Training Programme	3-day seminar in Singapore in March 2014	19	The seminar delved into the challenges and opportunities in integrating climate change issues (mitigation and adaptation) into local policies with a thematic focus on flood risk management.
12	Facilitating Private Sector Investment in Climate Change Projects in the Asia Pacific	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	2-day training course in Singapore in March 2014	22	The course discussed the facilitation of private sector investments in climate change; mitigation and adaptation projects through public sector interventions and regulation; mobilising private investments for climate change projects; and the development of new ideas for sourcing private sector finance for adaptation and mitigation efforts.
13	Sustainable Urban Transport Planning and Management	Singapore-United States Third Country Training Programme	2-week training course in Singapore between March and April 2014	17	The programme was designed to provide participants from ASEAN countries, particularly those in the Lower Mekong, with a broad perspective and better understanding of Singapore's and the United States' policies and best practices on effective planning and management of sustainable and integrated urban transport systems.
14	Capacity Building Training Course for SIDS Climate Change Negotiators	United Nations Development Programme (UNDP) and Government of Australia	5-day course in Singapore in April 2014	27	The course equipped SIDS negotiators with the skills to handle climate change negotiations at foras such as the annual UN climate change conference. Singapore also shared our experiences on climate change strategy, green buildings, transport management and water resources management.

Sino-Singapore Tianjin Eco-city

PM Lee Hsien Loong and PRC Premier Wen Jiabao jointly launched the Sino-Singapore Tianjin Eco-city (SSTEC) in November 2007. Our common aim was to create a model for sustainable development for other cities in China. As the second flagship Government-to-Government project between Singapore and China, the 30 km^2 SSTEC provides a platform for both countries to strengthen collaboration in environmental protection, resources and energy conservation, and in building a harmonious society. It was recognised by the New York Times in 2013 as the most successful eco-city project in China.

The SSTEC has served as reference for China's reforms in sustainable development and urbanisation. To ensure the SSTEC's continued relevance, both governments in 2013 endorsed the SSTEC's refreshed vision to be a leader in eco-development, a vibrant model satellite city, and a harmonious city with an innovative social governance framework. Both countries collaborate in diverse areas that include urban planning, water and waste management, and social development. Today, SSTEC residents live in 100% green buildings and actively practise recycling. There are also affordable public housing and attractive social amenities, based on Singapore's experience.

Bird's-eye view of the SSTEC in 2008. The original site comprised non-arable saline land and polluted water bodies.

Bird's-eye view of the SSTEC in 2014. The site has since been transformed into a green city with tree-lined roads and lushly landscaped housing estates.

FIRST BIENNIAL UPDATE REPORT

Under the United Nations Framework Convention on Climate Change

The Singapore River flows through the Central Business District into Marina Reservoir, which has the largest and most urbanised catchment in Singapore.

First Biennial Update Report

Chapter 1
National Circumstances

1 NATIONAL CIRCUMSTANCES

Country Profile

Singapore is a small island state in Southeast Asia and consists of one main island and more than 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 the Indonesian islands by the Straits of Singapore.

Land Area

The main island of Singapore is about 49km east to west and 25km from north to south with a coastline of 197km. The total land area (including that of smaller islands) is about 716km^2. Among the islands, the larger ones are Pulau Tekong (24.4km^2), Pulau Ubin (10.2km^2) and Sentosa (5km^2).

Singapore's surface reaches 163m at our 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 24.1°C. December and January are generally cooler months.[16]

With an annual rainfall of 2,352mm, there is no distinct dry season, with rainfall throughout the year. The heaviest monthly rainfall generally occurs from November to January. The drier months are usually July and February. The relatively wetter Northeast Monsoon 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.

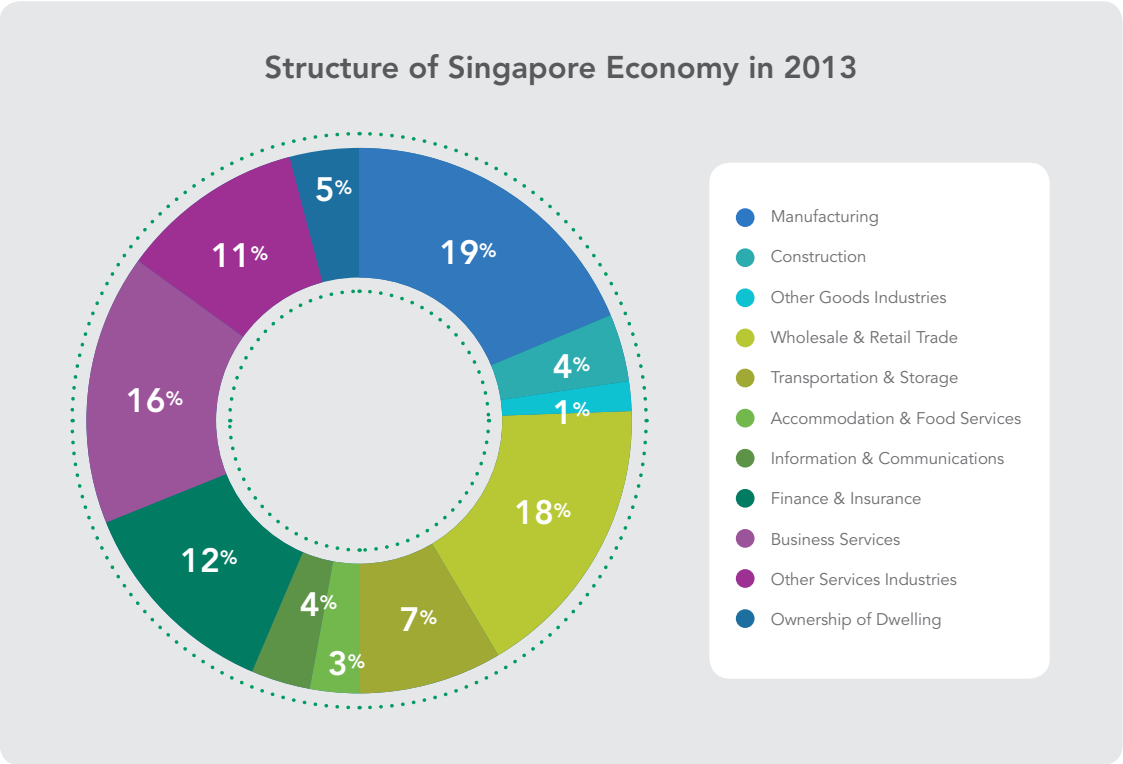
Population

As of 2013, Singapore's total population, including foreigners working in Singapore, is estimated at 5.4 million. The resident population, comprising Singapore citizens and permanent residents, is estimated at 3.8 million or 71% of the total population. Singapore's small land area also means that our population density of about 7,540 people per km^2 is one of the highest in the world.

Economy

Singapore is an export-oriented economy that is highly dependent on international trade. In 2013, Singapore's external trade amounted to S$980 billion, about 2.6 times the GDP of Singapore (S$370 billion). Over several decades, Singapore has built up a strong economy where manufacturing and wholesale & retail trade sectors comprised 19% and 18% of GDP respectively in 2013. 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, and our three refineries produce primarily for global export. Oil made up more than 20% of our total exports in 2013. Singapore's strategic geographical location has also enabled it to develop into a major air and sea transportation hub. The economic structure in 2013 is as shown.

[16] Refer to: http://app2.nea.gov.sg/weather-climate/climate-information/weather-statistics.



Water

Located in the equatorial rain belt, Singapore receives abundant rainfall annually. However, Singapore is considered to be a water-scarce country due to limited land to collect and store rainwater. To ensure water sustainability, Singapore has developed a diversified and robust supply of water through the Four National Taps, namely local catchment water, imported water, NEWater - high-grade reclaimed water produced from treated used water, and desalinated water.

Since 2011, the total water catchment area has been increased from half to two-thirds of Singapore's land surface with the completion of three reservoirs in urbanised areas. Despite our best efforts to maximise water supply from our local catchments, Singapore is still physically limited by our small land area, while demand for water continues to increase in tandem with economic and population growth. Currently, NEWater and desalination capacity is able to meet up to 30% and 25% of our water demand respectively. By 2060, we will expand NEWater and desalination capacities to meet up to 55% and 25% of water demand respectively.

One implication of using NEWater and desalinated water to augment Singapore's water supply is that the production of NEWater and desalinated water is more energy-intensive as compared to treating water from the local catchment. To improve energy efficiency of these water treatment processes, Singapore is investing in research and development (R&D) to develop low-energy desalination solutions. For instance, one project using electrochemical desalting aims to reduce energy usage to less than half of current membrane-based desalination methods. Another research area is biomimicry (the study of natural desalination processes in mangrove plants and

marine fishes), which has the potential to reduce the required energy further. However, these low-energy solutions will take time to develop and mature before being fully deployed.

In addition to improving energy efficiency, it is also important to manage water demand. Through wide-ranging water conservation measures, Singapore's per capita domestic water consumption reduced from 165 litres per day in 2003 to 151 litres per day in 2013. The target is to lower it to 147 litres by 2020 and 140 litres by 2030. The use of alternative sources of water, such as ongoing large-scale water recycling to produce NEWater and the use of seawater for industrial cooling, helps to free up potable water demand, thus reducing Singapore's water footprint significantly. More efficient water solutions such as localised water recycling to conserve water are also encouraged. Another critical component of demand management is the reduction of unaccounted-for-water (UFW). Through holistic and efficient water demand management strategies, Singapore has substantially reduced UFW from 11% in the 1980s to about 5% at present. The number of leaks in Singapore, around 6 leaks/100km/year, is low when compared to other countries.

Crest gates at Marina Barrage are lowered when it rains heavily during low-tide to release excess water from the Marina Reservoir into the sea.

Singapore's National Circumstances and Constraints

Singapore contributes less than 0.2% of global emissions. We will continue to take steps to reduce our carbon emissions in the coming decades. The extent of reductions will depend on our national circumstances, past mitigation efforts, geographical constraints, and the limited scope for non-fossil fuel alternatives.

Historically, our strategic geographical position along the East-West trade routes has made Singapore a natural location for oil storage and refining facilities serving the region. Building on our position as a key regional port, the refining and petrochemical plants help create synergies and are part of a business supply network in Southeast Asia, the Western Pacific, South Asia and Australasia. The refining and petrochemical sector is a large source of our carbon emissions. Singapore has been working to improve our levels of energy efficiency. This is an ongoing and continuous effort.

Singapore has taken early measures on sustainable development such as managing the growth of our vehicle population. In addition, we have optimised the use of our scarce land through integrated urban planning. As Singapore lacks a hinterland, our small land area has to support the entire spectrum of activities in a country — beyond transport, housing, offices, shops and industries, land is also required for reservoirs and water catchment areas, as well as security.

As Singapore is a small, alternative-energy disadvantaged city-state, there will be limits to the extent of emissions reductions that can be undertaken. Given our small size and dense urban landscape, there are challenges to use alternative energy sources such as solar energy on a wide scale. Such difficulties in switching to alternatives are recognised by the United Nations Framework Convention on Climate Change (UNFCCC), as described in Articles 4.8 and 4.10 of the Convention.

Notwithstanding these natural circumstances and constraints, Singapore's longstanding focus on sustainable development and environmental quality has helped to significantly moderate our carbon emissions growth. From 2000 to 2005, our emissions grew by 1.1% per year (from 39 million tonnes in 2000 to 41 million tonnes in 2005), mainly due to the one-off fuel switch to natural gas in the power sector, much lower than our GDP growth of 4.9% per year over the same period. Previously, our historical rate of emissions growth was about 6.4% per year from 1994 to 2000.

National Circumstances in the United Nations Framework Convention on Climate Change (UNFCCC)

A Party's national circumstances are recognised by the United Nations Framework Convention on Climate Change (UNFCCC). Convention Article 4.8 and 4.10 explicitly take into consideration developing countries' national circumstances – especially small island countries, countries with low-lying coastal areas, land-locked and transit countries, and countries disadvantaged in the use of alternative energy sources, amongst others.

Article 4.8: "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: "The Parties shall, in accordance with Article 10, 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. This applies notably to Parties with 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.**"

Singapore's Limited Access to Alternative Energy Sources

Given our small size and dense urban landscape, there are challenges to using alternative energy sources such as solar and nuclear. Singapore's geographical features also limit our access to geothermal resources, hydroelectricity, wind, tidal and wave power.

Biomass

Biomass, which is used by many countries with available land mass as an alternative to fossil fuel, is not viable as a significant energy resource. Singapore already converts much of our waste to energy, providing about 2% of our electricity needs. However, Singapore's lack of domestic

biomass sources and available land may limit the future growth potential of biomass power generation. Nonetheless, Singapore will continue to study and monitor developments in this area.

Carbon Capture, Storage and Utilisation (CCSU)

A lack of suitable storage sites and low-carbon concentrations in emissions limit the cost-effectiveness of CCSU as a mitigation measure for Singapore. However, research institutions in Singapore are actively carrying out related research to ensure that CCSU remains an option should circumstances become conducive for the deployment of CCSU.

Geothermal

Singapore lacks conventional geothermal resources. In addition, unconventional geothermal resources cannot be utilised in a cost-effective manner with current technologies.

Hydroelectric

Hydroelectricity harnesses the energy of flowing water for the generation of electricity. Much of Singapore is generally flat and less than 15m above sea level. The absence of major river systems means that hydroelectricity is not a viable option in Singapore.

Marine (tidal and wave power)

The tidal range (difference between high and low tide) is about 1.7m, well below the 4m tidal range that is typically required for commercial tidal power generation. Wave power from surrounding waters is limited as Singapore is surrounded by landed masses resulting in relatively calm waters. In addition, wave, tidal and ocean thermal have limited application as much of our sea space is used for ports, anchorage and international shipping lanes.

Nuclear

Nuclear energy could offer increased energy security and is a low-carbon power generation option. However, the risks to Singapore, given that the country is small and densely populated, still outweigh the benefits at this point. A recent nuclear energy pre-feasibility study concluded that nuclear energy technologies presently available are not yet suitable for deployment in Singapore. Nonetheless, Singapore will continue to monitor developments and will focus on research and developing capabilities to keep abreast of progress in nuclear energy technologies so as to keep our options open for the future.

Solar

Solar energy is the most viable source of renewable/alternative energy in Singapore, even though there are space constraints to its deployment due to Singapore's compact and dense urban landscape. Singapore has been exploring ways to increase our use of solar energy and manage the impact of intermittency. In addition, Singapore has recently enhanced the regulatory framework for intermittent generation sources, so as to maximise solar deployment potential in Singapore.

The government is also leading the SolarNova Programme to accelerate solar deployment through promoting and aggregating solar demand across agencies, with the aim of increasing solar deployment to 350 megawatt-peak (MWp) by 2020. Besides these, we are actively investing in R&D and test-bedding to improve the efficiency and lower the price of solar technologies.

For example, we have launched solar capability building schemes and are conducting solar test beds in public housing precincts to better understand the technical viability of solar technologies under local conditions, as well as the commercial viability of innovative business models. Furthermore, we are also studying how energy storage solutions can be used in Singapore's context to manage intermittency.

Wind

Harnessing wind energy is also not viable, given our low average wind speeds of about 2m/s to 3m/s and lack of land for large-scale application of wind turbines. Most commercial wind farms leverage average wind speeds of at least 6m/s, while prime wind sites require annual average wind speeds in excess of 7.5m/s. In addition, there are challenges to harnessing offshore winds due to busy maritime traffic in our waters.

Asia's Greenest City

According to the 2011 Siemens/EIU Asian Green City Index, Singapore is Asia's greenest metropolis, and the only city assessed to perform well above average in the overall rankings. Highlighting our sound policies as well as our achievements in efficient energy use, the study also cited Singapore for "having an energy reduction strategy, for making efforts to consume energy more efficiently, for having a climate change action plan and for signing up to international environmental covenants".

In the World Economic Forum's Global Competitiveness Report 2011–2012, Singapore ranked second in both the Global Competitiveness Index and the newly introduced Sustainable Competitiveness Index, which takes into account countries' environmental policy, resource

efficiency and environmental degradation, alongside other economic and social indicators. Singapore also ranked third overall in the Economist Intelligence Unit's "Global City Competitiveness Index" in 2012 and is the highest placed Asian city. The report highlighted Singapore's focus on environmental sustainability as a key aspect of liveability, which was emphasised very early on from the 1960s.

Singapore's immutable geographical realities, coupled with our historical economic development, are significant determinants. Nonetheless, we remain committed to stabilising our long term emissions. We have invested significantly in energy-related R&D over the years. For example, the National Innovation Challenge on "Energy Resilience for Sustainable Growth" aims to develop cost-competitive energy solutions for deployment within 20 years to help Singapore improve energy efficiency, reduce carbon emissions and increase energy options.

These efforts will take time, given the need for significant improvement in relevant technologies. Singapore serves as a test-bed for innovative clean technology solutions developed specifically for use in cities. Should these efforts bear results, Singapore and other countries with similar circumstances will benefit from these urban solutions.

Our constraints and unique circumstances mean that Singapore's emissions will not dip below historical levels in the near future. Nonetheless, Singapore is putting in a major effort to stabilise our long-term emissions.

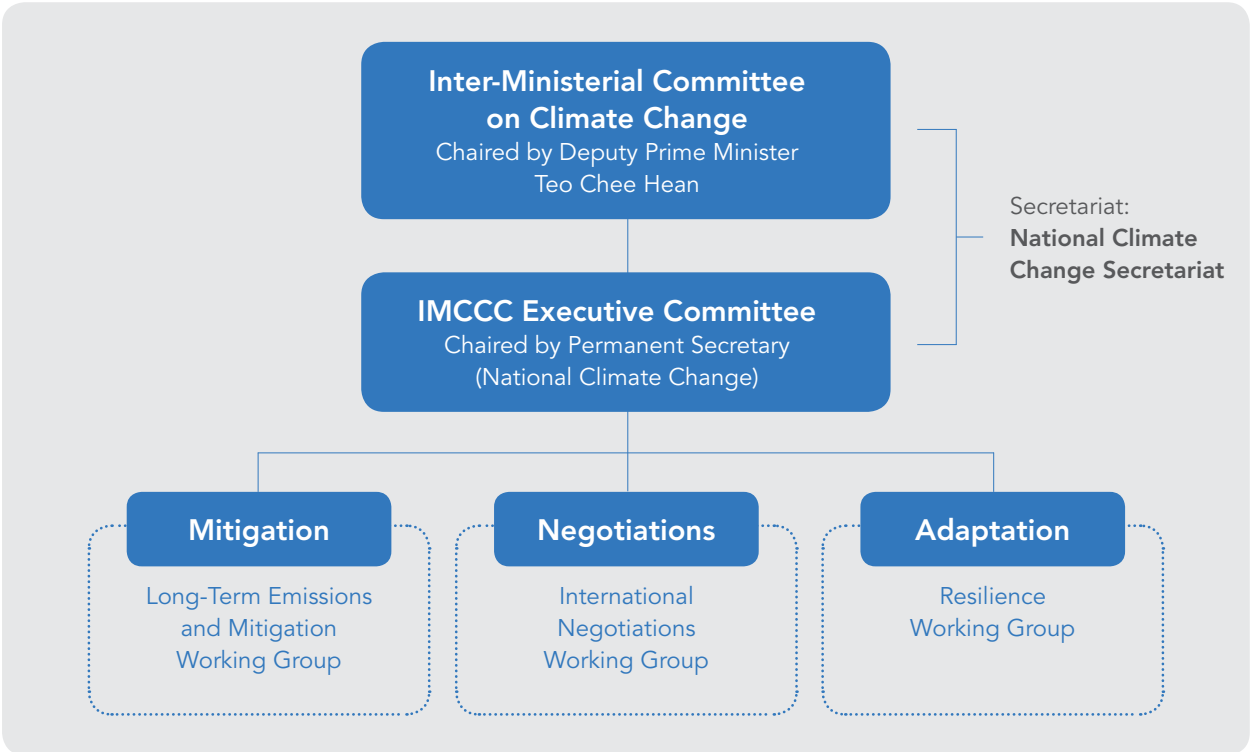
Punggol Waterway - awarded the Global Superior Achievement Award in 2012 by the International Water Association in recognition of excellence and innovation in water engineering projects.

Institutional Arrangements

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 approach to climate change. The IMCCC is chaired by the Deputy Prime Minister, Coordinating Minister for National Security and Minister for Home Affairs. It 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. The IMCCC is supported by an Executive Committee (Exco) comprising the Permanent Secretaries of the respective Ministries. The IMCCC Exco oversees the work of the International Negotiations Working Group, Long Term Emissions and Mitigation Working Group, and the Resilience Working Group.

The International Negotiations Working Group develops Singapore's international climate change negotiations strategy under the UNFCCC. The Long Term Emissions and Mitigation Working Group studies how Singapore can stabilise our long-term emissions. It examines options for emission reduction and identifies the capabilities, infrastructure and policies needed for long-term mitigation. The Resilience Working Group studies Singapore's vulnerability to the effects of climate change and recommends long-term plans that ensure the nation's adaptation to future environmental changes.

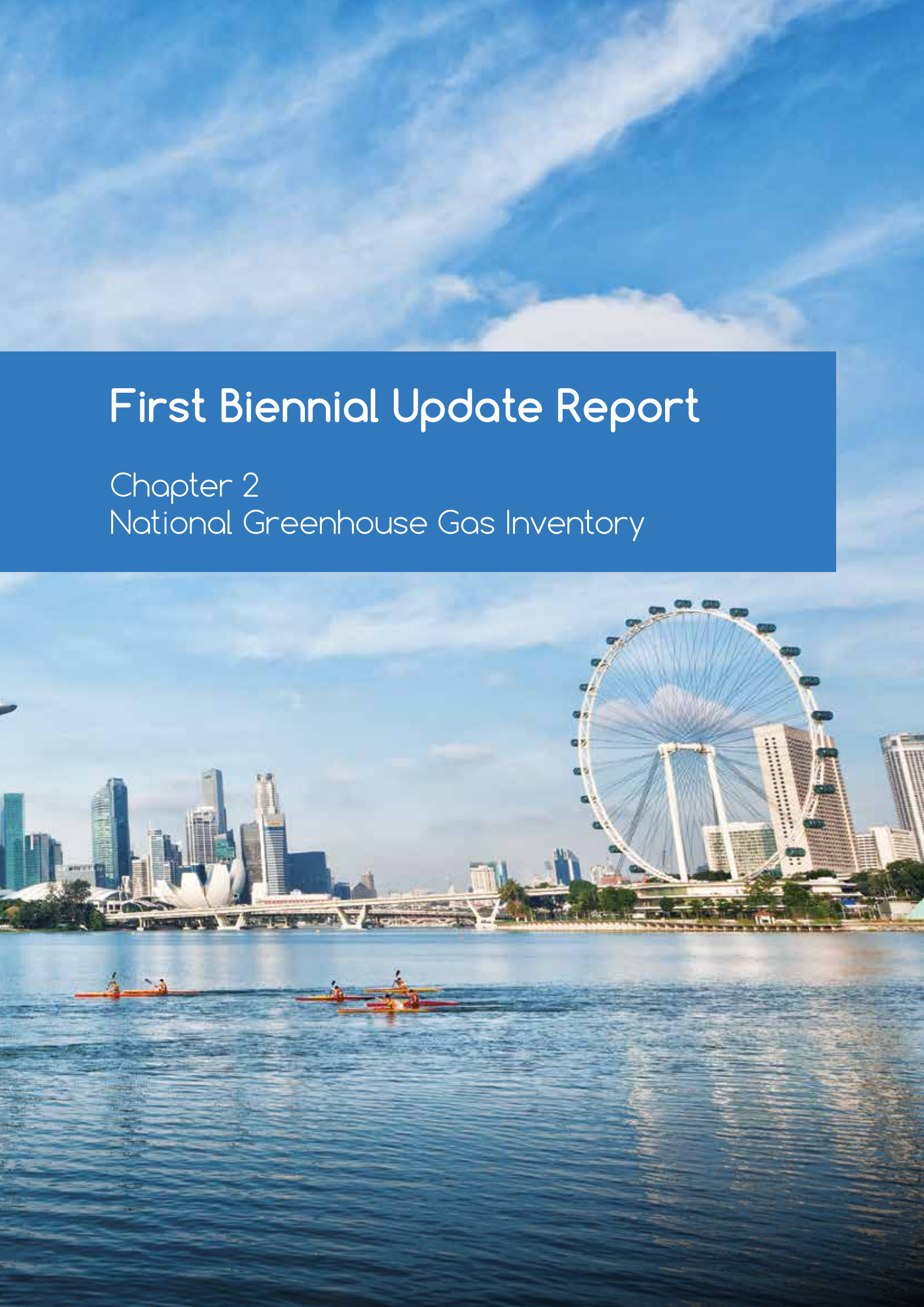
To ensure the effective coordination on Singapore's domestic and international policies, plans and actions on climate change, the National Climate Change Secretariat (NCCS) was established as a dedicated unit in July 2010 under the Prime Minister's Office. The positioning of NCCS underscores the importance that Singapore places on climate change.



City View from Marina Gardens East.

First Biennial Update Report

Chapter 2
National Greenhouse Gas Inventory



2 NATIONAL GREENHOUSE GAS INVENTORY

The most significant greenhouse gas (GHG) emitted in Singapore is carbon dioxide, primarily produced by the burning of fossil fuels to generate energy used by the industry, building, household and transport sectors. The greenhouse gas emissions from agriculture, land-use change and forestry sectors are negligible in comparison with the size of carbon stocks and in comparison with other economic sectors.

Methodology Used

Singapore's emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) were estimated using the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, in line with the user manual for the guidelines on national communications from non-Annex I Parties. Emission estimates were based on the sectoral approach and were made using the default conversion and emission factors provided in the Revised 1996 IPCC Guidelines. The Tier 1 methodology was used for most emission estimates. The Tier 2 methodology was used for estimating emissions of CH_4 and N_2O from the combustion of petrol and diesel in land transport, in conjunction with vehicle statistics. The figures shown in this chapter refer to sectoral approach figures.

The emissions from waste incineration and hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) from integrated circuit and semiconductor production were estimated using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories as there are no 1996 IPCC factors.

The emissions of HFCs, PFCs and SF_6 were estimated using the Tier 2 methodology and default conversion and emission factors from the 2006 IPCC Guidelines.

In addition, the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories were applied to improve the transparency, consistency, comparability, completeness and accuracy of the inventory.

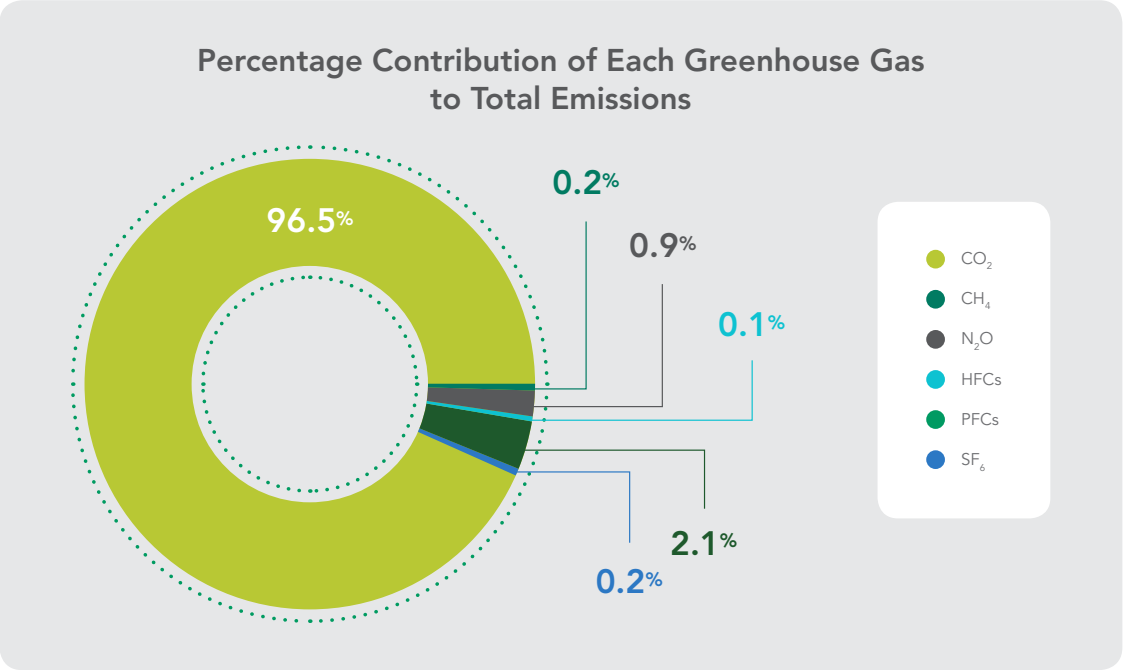
The estimated CH_4, N_2O, HFCs, PFCs and SF_6 emissions were converted to CO_2-equivalent using 1995 IPCC global warming potential (GWP) values based on the effects of greenhouse gases over a 100-year time horizon in the table below.

Greenhouse Gas	Chemical Formula	GWP
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Hydrofluorocarbons	HFCs	140 – 11,700
Perfluorocarbons	PFCs	6,500 – 9,200
Sulphur hexafluoride	SF_6	23,900

Singapore's Emissions for 2010

Sectoral Emissions

Singapore's greenhouse gas emissions for 2010 totalled 46,831.68 gigagram (Gg) CO_2-equivalent. The breakdown of emissions by type of gas is as shown.



A breakdown of the total greenhouse gas emissions by sources for 2010 in gigagram (Gg) CO_2-equivalent is shown in the table below.

Greenhouse Gas Source and Sink Categories[17]	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Total (Net) National Emissions (Gg CO_2-equivalent per year)	**45,202.88**	**113.91**	**400.79**	**39.94**	**987.91**	**86.25**
All Energy	**45,202.88**	**42.70**	**304.99**			
Fuel combustion	**45,047.04**	**42.70**	**304.99**			
Energy and transformation industries	20,790.82	10.14	77.24			
Industry	16,945.97	8.06	14.13			
Transport	6,722.69	24.46	213.62			
Commercial-institutional	404.23	0.03	0.01			
Residential	183.33					
Fugitive fuel emission	**155.84**					
Oil and natural gas systems[18]	155.84					
Industrial Processes				**39.94**	**987.91**	**86.25**
Waste		**71.21**	**95.80**			
Wastewater handling		71.21	95.80			

The 2010 greenhouse gas inventory worksheets are appended in the Annex. A breakdown of the total greenhouse gas emissions by sources for the reporting years of the 1st and 2nd National Communications (1994 and 2000) in gigagram (Gg) CO_2-equivalent can also be found in the Annex.

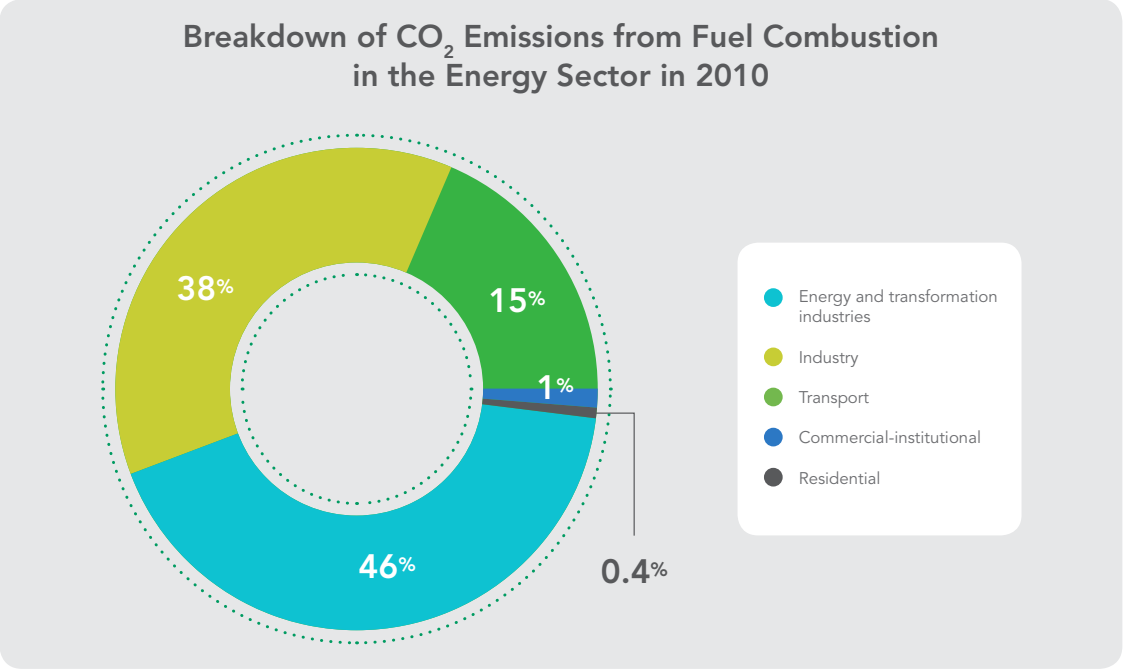
[17] The greenhouse gas emissions from agriculture, land-use change and forestry sectors are likely to be small as there are no commercial forestry or plantations in Singapore. A long-term programme of monitoring carbon storage and carbon fluxes related to land-use change and forestry has been initiated and will facilitate more detailed greenhouse gas data reporting of this sector in due course.

[18] Fugutive fuel emissions from oil and natural gas systems are based on company-level data.

Breakdown of Emissions by IPCC Sector

All Energy

The combustion of fossil fuels to generate energy is the major source of CO_2 emissions in Singapore. The amount of CO_2 emitted from the energy sector (fuel combustion) in 2010 was 45,047.04Gg. The contribution of CO_2 emissions from fuel combustion in the energy sector in 2010 is as shown.



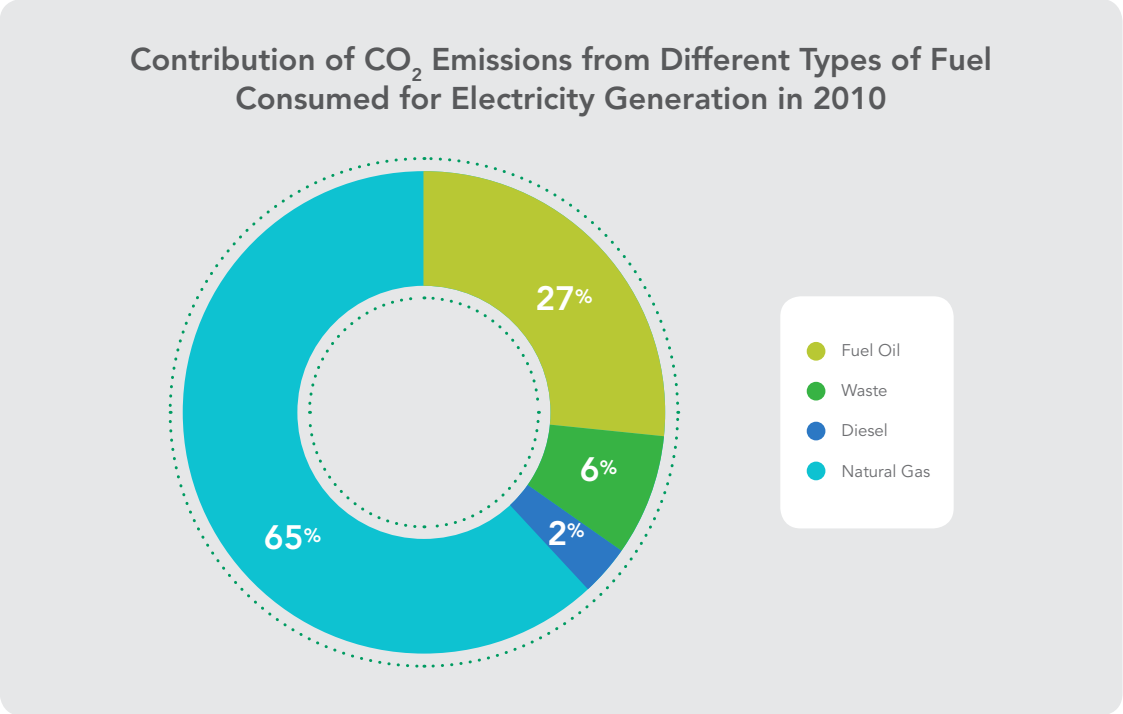
As heat from the incineration of waste is recovered to produce electricity in Singapore, CO_2 and N_2O emissions from waste incineration are reported in the energy sector. According to the IPCC Guidelines, CO_2 emissions from waste incineration are estimated from the portion of the waste that is fossil fuel based and the biomass fraction is excluded. Waste incineration was estimated to contribute 1,183.86Gg of CO_2 to the total greenhouse gas emissions in 2010.

As heat from the incineration of sludge from wastewater processes is recovered in Singapore, CH_4 and N_2O emissions from sludge incineration are reported in the energy sector.

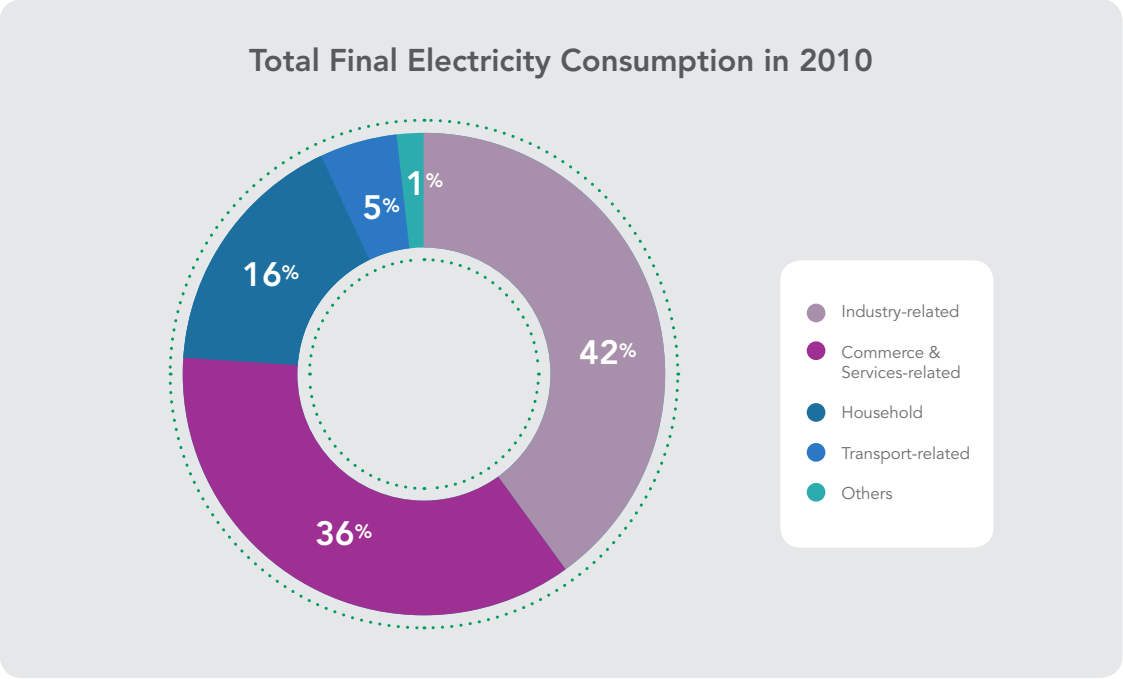
Fugitive emissions from flaring in the oil industry were estimated to contribute 155.84Gg of CO_2 emissions.

Electricity Generation

In 2010, the total amount of CO_2 emitted from electricity generation was 20,790.82Gg. The contribution of CO_2 emissions from different types of fuel combusted for electricity generation in 2010 is as shown.



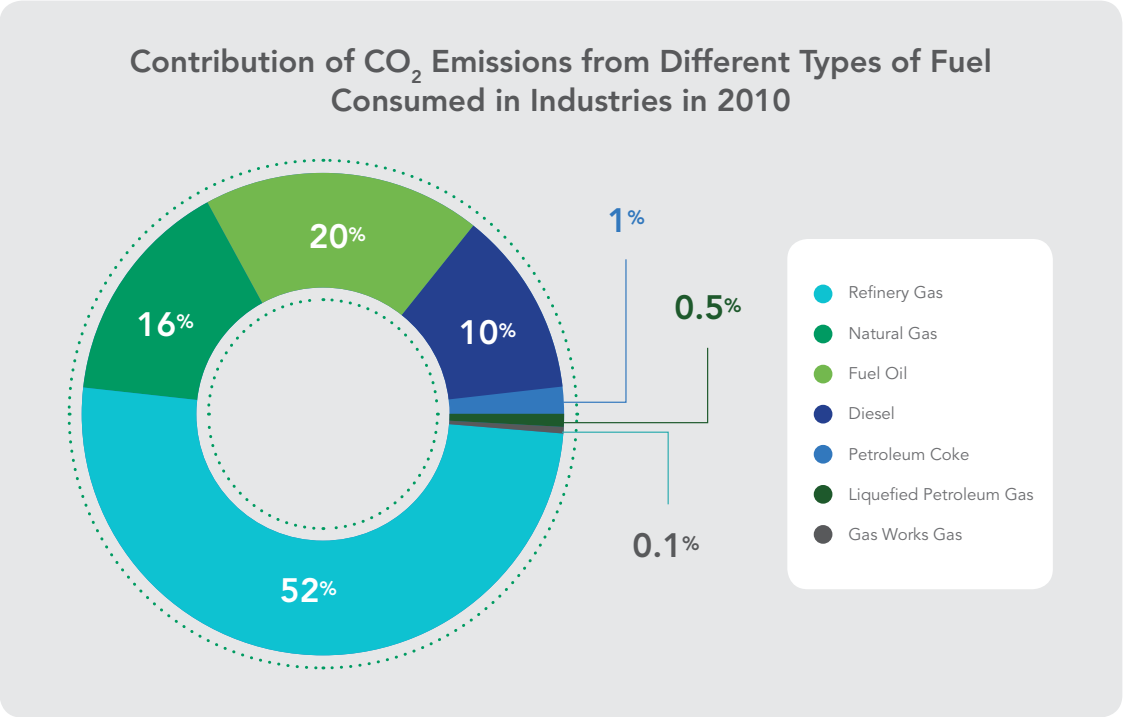
A total of 42,289.01 gigawatts-hours (GWh) of electricity was consumed in 2010. The consumption of electricity in the various end-use sectors is as shown.



Industry

The majority of the direct emissions from the industrial sector is from the combustion of primary fuels by the refining and petrochemical sector. While Singapore does not produce any oil or gas, we are a major oil refining and petrochemical centre that serves the global market.

The contribution of CO_2 emissions from different types of fuel combusted in industries in 2010 is as shown.

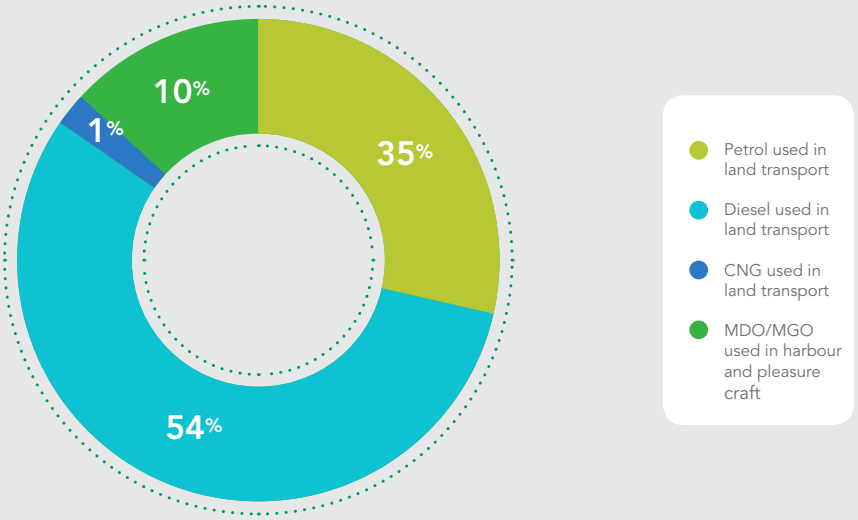


Transport

In 2010, Singapore had a network of 3,377km of paved public roads and a population of 945,829 motor vehicles. These motor vehicles consumed diesel, petrol and compressed natural gas (CNG), utilising 1,157.70 kilo-tonnes (kt) of diesel, 760.5kt of petrol and 20.68 kilo-tonnes of oil equivalent (ktoe) of CNG in 2010. This contributed 6,064.13Gg of CO_2 to the total greenhouse gas emissions. Land transport was estimated to contribute 211.95Gg CO_2-equivalent of N_2O and 23.52Gg CO_2-equivalent of CH_4 to the total greenhouse gas emissions in 2010, based on a 100-year time horizon, where N_2O has a GWP of 310 and CH_4 has a GWP of 21. The total amount of N_2O and CH_4 emissions from land transport is equivalent to 235.47Gg of CO_2.

Marine Gas Oil/Marine Diesel Oil was consumed by harbour and pleasure crafts plying within the waters of Singapore. These harbour and pleasure crafts contributed 658.56Gg of CO_2, 1.67Gg CO_2-equivalent of N_2O and 0.94Gg CO_2-equivalent of CH_4 to the total amount of greenhouse gas emissions in 2010. The percentage contribution of harbour and pleasure craft and motor vehicles to CO_2 emissions from the combustion of fuels in the transport sector is as shown.

Contribution of CO_2 Emissions from Different Types of Fuel Consumed in the Transport Sector in 2010

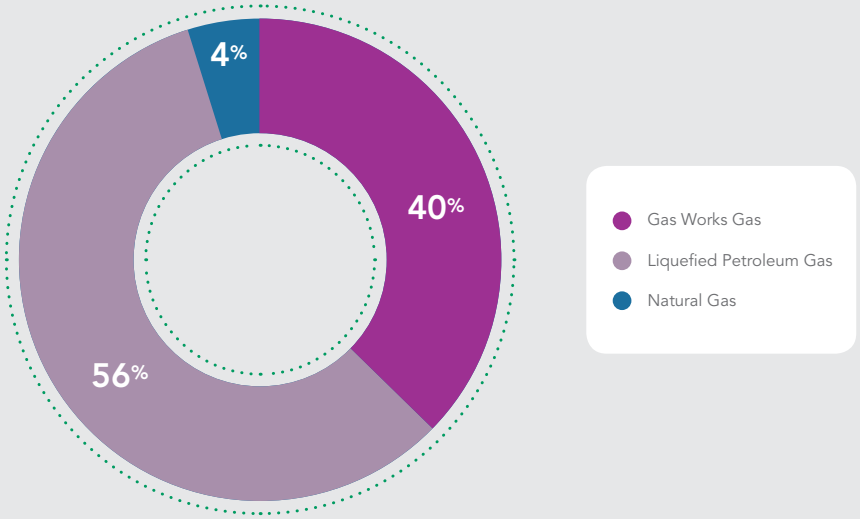


Commercial-Institutional and Residential

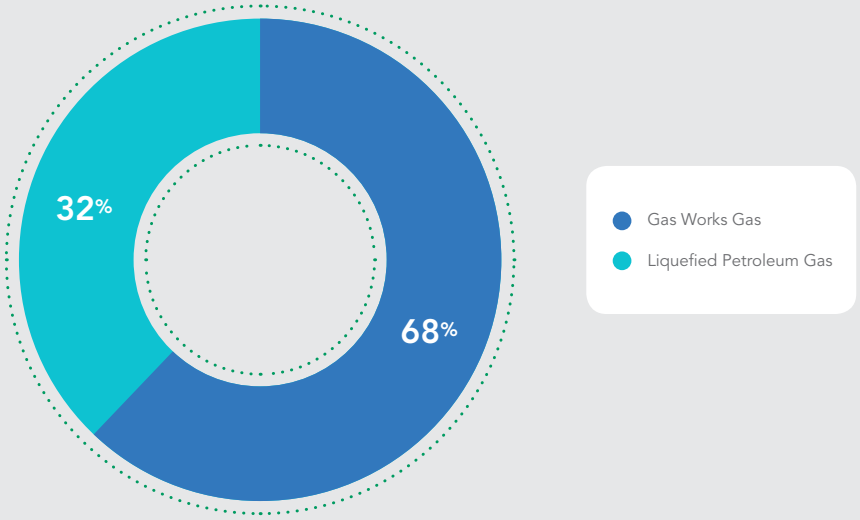
Emissions from the commercial and residential sectors were from the use of Liquefied Petroleum Gas (LPG) and Gas Works Gas[19], mainly for cooking and hot water systems. In 2010, 1,438.91GWh of Gas Works Gas, 96.05kt of LPG and 7.1ktoe of natural gas were consumed by the commercial and residential sectors in total. This was equivalent to 587.56Gg of CO_2 emissions. The breakdown of CO_2 emissions by fuel type in the commercial and residential sectors are as shown.

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

Contribution of CO_2 Emissions from Different Types of Fuel Consumed in the Commercial-institutional Sector in 2010

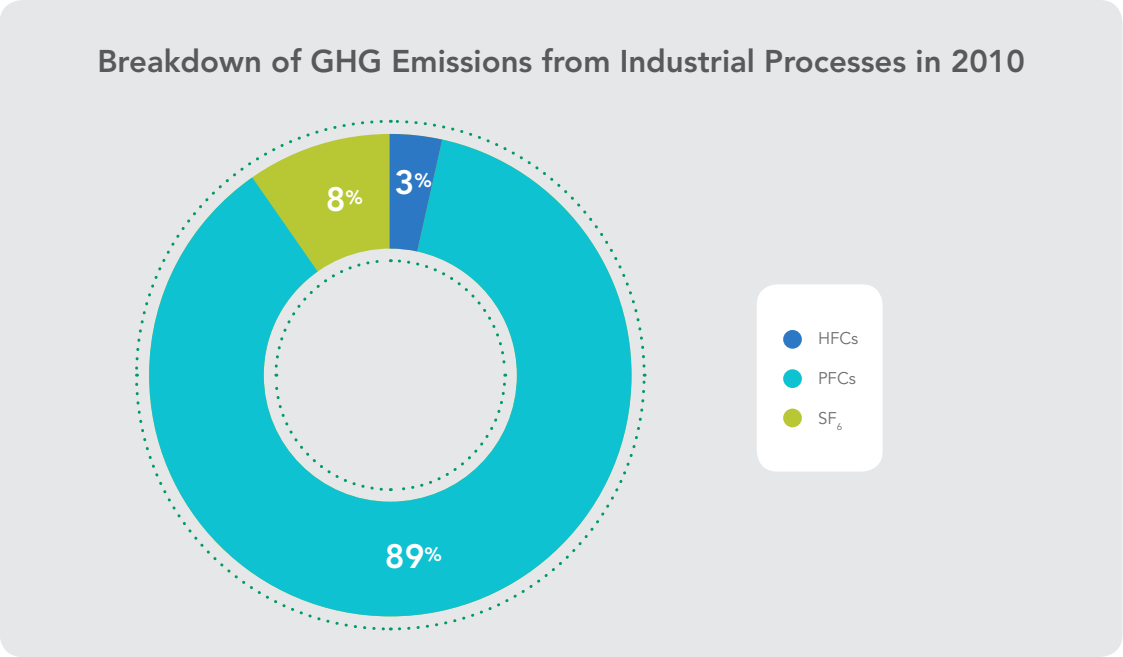


Contribution of CO_2 Emissions from Different Types of Fuel Consumed in the Residential Sector in 2010



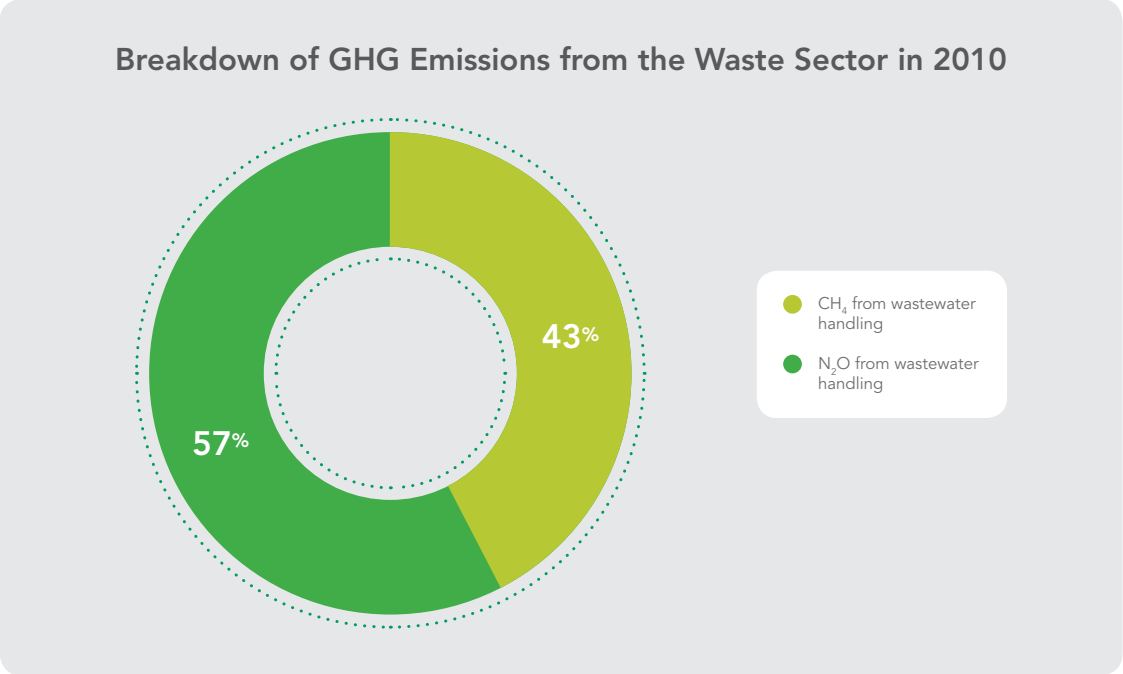
Industrial Processes

In the semiconductor industry, although HFCs, PFCs and SF_6 were 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 1,114.10Gg of CO_2-equivalent emissions. The percentage contribution by type of gas is as shown.



Waste

Greenhouse gas emissions from the waste sector for the year 2010 are summarised in the sections below. The breakdown of emissions from the waste sector is shown in the chart below.



Solid Waste Management

Singapore has adopted waste-to-energy incineration technology to reduce the volume of waste disposed at landfill since 1970s. As heat from the incineration of waste is recovered to produce electricity, according to the Revised 1996 IPCC Guidelines, CO_2 and N_2O emissions from waste incineration are reported in the energy sector.

Today, all incinerable wastes that are not recycled are disposed at the waste-to-energy incineration plants. Only non-incinerable waste and ash from the incineration process are disposed at the off-shore Semakau Landfill. Hence, CH_4 emissions from the Semakau Landfill is insignificant.

According to the IPCC Guidelines, CH_4 emissions from waste incineration are not likely to be significant because of the combustion conditions in incinerators. N_2O emissions were estimated based on the amount of waste incinerated at the waste-to-energy incineration plants.

Refuse bunker in Singapore's waste-to-energy incineration plant.

Non-incinerable waste and ash from the incineration process are disposed of at the off-shore Semakau Landfill.

Wastewater Handling

From 1985 to 2008, treated sludge was applied on reclaimed land sites as a soil conditioner. Residual CH_4 emissions were due to anaerobic decay of the organic contents in the sludge from these sites. Since 2009, direct methane emissions from sewage sludge are significantly reduced by incinerating the sludge[20]. Sumitomo Mitsui Banking Corporation and ECO-Special Waste Management (ECO-SWM) have collaborated to develop one of Southeast Asia's largest sewage sludge dehydration and incineration projects in Singapore.

[20] In accordance with the 2000 IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, emissions from the incineration of sewage sludge for year 2010 were estimated by PUB based on the backward trend extrapolation of available data from Sep 2010 to Dec 2010. The emissions were from the sludge incineration plant operated by ECO-SWM which was registered as a CDM project on 13 Sep 2010.

ECO-Special Waste Management (ECO-SWM) sludge incineration facility - methane emissions from sewage sludge are reduced by incinerating the sludge.

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. CO_2 produced from the combustion of biogas is not counted in the national inventory as it is part of the natural carbon cycle of decomposition. Fugitive CH_4 emission is negligible as all unused biogas is flared.

N_2O emissions were from human sewage and estimated based on annual per capita protein intake data from the UN Food and Agriculture Organisation (FAO).[21]

Agriculture

The greenhouse gas emissions from agriculture are negligible in comparison with the size of carbon stocks and in comparison with other economic sectors. 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.

[21] Reports by the UN Food and Agriculture Organisation (FAO) estimated Southeast Asia's protein intake to be 66g/capita/day. This is used as an estimate of Singapore's 2010 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 FAO and posted in the FAO website: www.fao.org.

Land Use Change and Forestry

Singapore has begun a long-term programme to monitor and report carbon storage and carbon fluxes related to land use change and forestry. As there are no commercial forestry or plantations in Singapore, the national figures are anticipated to be small.

With careful land use planning, Singapore has been able to commit 9% of the total land area to parks and nature conservation. This is part of the government's programme to provide a pleasant living environment in a city state. Trees and shrubs along roadsides, outside the forest environment, constitute part of our carbon store. In addition there are more than 2,500ha of forests safeguarded within the nature reserves that are conserved for ecological, educational, recreational and scientific purposes.

Bukit Timah Nature Reserve - home to 40% of Singapore's flora and fauna.

Key Category Analysis

The 2000 IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gases Inventories recommends the use of the Key Category Analysis (KCA) to prioritise key categories in the national inventory. Key categories under the guidelines are sectors whose emissions when summed in descending order of magnitude add up to 95% of total greenhouse gas emissions.

All of Singapore's key categories originate from energy consumption activities which primarily produce CO_2 except the 10th key category which refers to emissions of PFCs from industrial processes. PFCs are used and emitted by companies which manufacture semiconductors and integrated circuits. The main contributor to greenhouse gas emissions (29.0%) is the combustion of natural gas to generate electricity.

Key Category Analysis						
	IPCC Category		Type of Greenhouse Gas	Emissions (kt CO_2-eq)	Percentage Contribution	Cumulative
1	Energy and Transformation Industries	Natural gas	CO_2	13,554.01	29.0%	29.0%
2	Industry	Refinery gas	CO_2	8,879.88	19.0%	48.0%
3	Energy and Transformation Industries	Fuel oil	CO_2	5,611.21	12.0%	60.0%
4	Land Transport	Diesel	CO_2	3,678.25	7.9%	67.8%
5	Industry	Fuel oil	CO_2	3,323.79	7.1%	74.9%
6	Industry	Natural gas	CO_2	2,774.92	5.9%	80.9%
7	Land Transport	Petrol	CO_2	2,337.56	5.0%	85.9%
8	Industry	Diesel	CO_2	1,613.96	3.5%	89.3%
9	Energy and Transformation Industries	Municipal Solid Waste[22]	CO_2	1,183.86	2.5%	91.8%
10	Industry	-	PFCs	987.91	2.1%	94.0%
11	Transport (marine craft)	Diesel	CO_2	658.56	1.4%	95.4%
	All Others	-	Greenhouse gases	2,227.77	4.6%	100%

[22] According to the IPCC Guidelines, CO_2 emissions from waste incineration are estimated from the portion of waste that is fossil fuel based.

Uncertainty

Singapore's national inventory was assessed based on three levels of confidence as described in the Revised 1996 IPCC Guidelines, namely H for High confidence in estimation, M for Medium confidence in estimation and L for Low confidence in estimation.

Data for 99.6% of greenhouse gas emissions has a confidence level of either "medium" or "high". A large proportion of these emissions are from fuel combustion. The collection of fuel combustion data through Acts under the Energy Market Authority and the National Environment Agency strengthened the confidence in the data and formed the basis for the high confidence in the greenhouse gas emissions. Data collected under surveys were assessed to be of medium confidence level. Quality control and quality assurance procedures outlined in the 2000 IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories were also applied to minimise human errors during inventory compilation and to ensure that the inventory is complete, accurate and consistent.

The greenhouse gas emissions that were assessed to be of lower confidence accounted for about 0.4% of total emissions. The conservative level of confidence reflected the uncertainties for these emission estimates. Methodological issues such as the high uncertainties associated with IPCC default emission factors used for the calculation of CH_4 and N_2O emissions from the combustion of fuels and proxy data used to estimate N_2O emissions from wastewater handling[23] resulted in lower levels of confidence for those categories. A higher tier method was used to reduce the uncertainty in the emission estimates for CH_4 and N_2O from the combustion of fuels.

[23] For example, estimates of protein intake in Southeast Asia by the Food and Agriculture Organization of the United Nations (FAO) were used instead of Singapore-specific data in the estimation of N_2O emissions from wastewater handling.

Confidence Levels of Data		
Greenhouse Gas Source and Sink Categories	**Confidence Level**	**% of Total GHG Emissions**
All Energy		97.3%
Fuel Combustion		
Energy and transformation industries	H	44.6%
Industry	M	36.2%
Transport	M	14.9%
Commercial-institutional	H	0.9%
Residential	H	0.4%
Fugitive fuel emission		
Oil and natural gas systems	M	0.3%
Industrial Processes		2.4%
Integrated Circuit or Semiconductor Production	M	2.4%
Waste		0.4%
Wastewater handling	L	0.4%

Time Series of Greenhouse Gas Emissions (2000-2010)

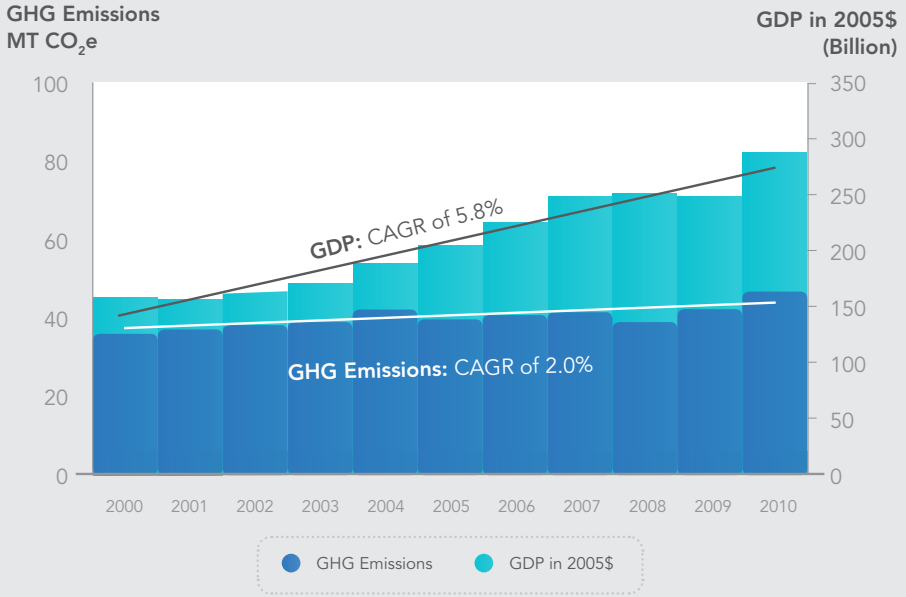
From 2000 to 2010, Singapore's economy grew at a compounded annual growth rate (CAGR) of 5.8%, while real GDP levels (in 2005 dollars) increased by 76% from S$167 billion in 2000 to S$294 billion in 2010. In the same period, Singapore's greenhouse gas emissions grew at a slower rate with a CAGR of 2.0%, and an increase of 21% (8,042Gg CO_2-equivalent) from 2000 to 2010.

As an open trade-oriented economy, Singapore's GDP growth volatility is much higher than that of larger economies[24]. Singapore's GDP is sensitive to changes in the global economy as emissions attributable to economic activity makes up a large proportion of Singapore's emissions. Hence, our emissions trajectory can be affected by external economic conditions and events. For example, the uptick in emissions in 2010 can be attributed to Singapore's strong recovery after the Global Financial Crisis in 2008 and 2009, when GDP grew by 15.2% in 2010 after contracting by 0.6% in 2009.

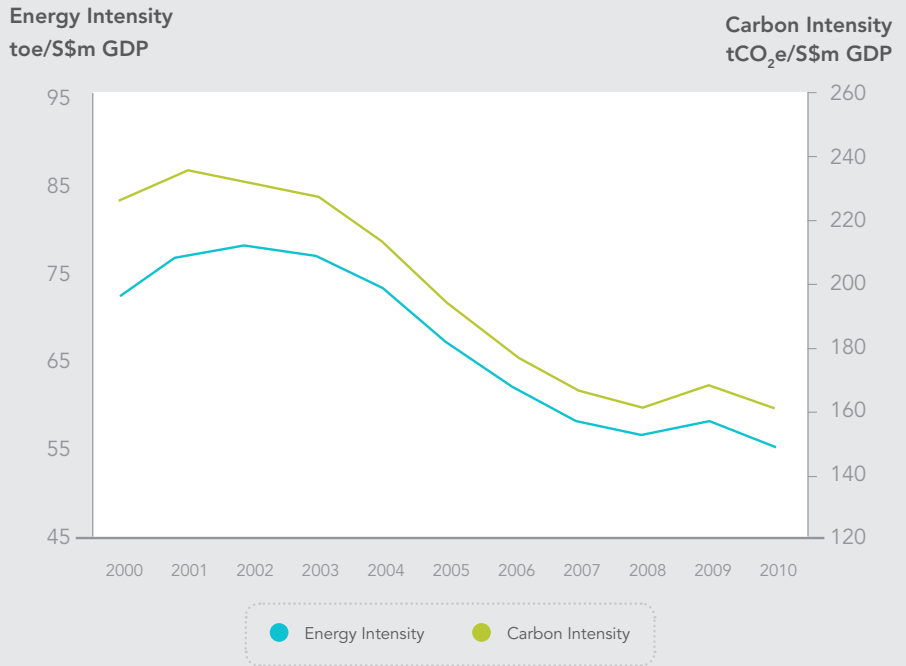
[24] "Is smoother always better? Understanding Singapore's volatility-growth relationship", Shruthi Jayaram, Titus Lee and Thia Jang Ping, Economic Survey of Singapore 2009.

Overall, carbon intensity decreased by 30% from 2000 to 2010 while energy intensity decreased by 24%. Some of the key policy initiatives implemented during this period included a switch in fuel mix from fuel oil to natural gas which is a cleaner fuel source, as well as introducing various schemes promoting energy efficiency throughout the decade, such as the Green Mark Scheme for buildings, and the Grant for Energy Efficient Technologies (GREET) for industry.

Time Series of Greenhouse Gas Emissions

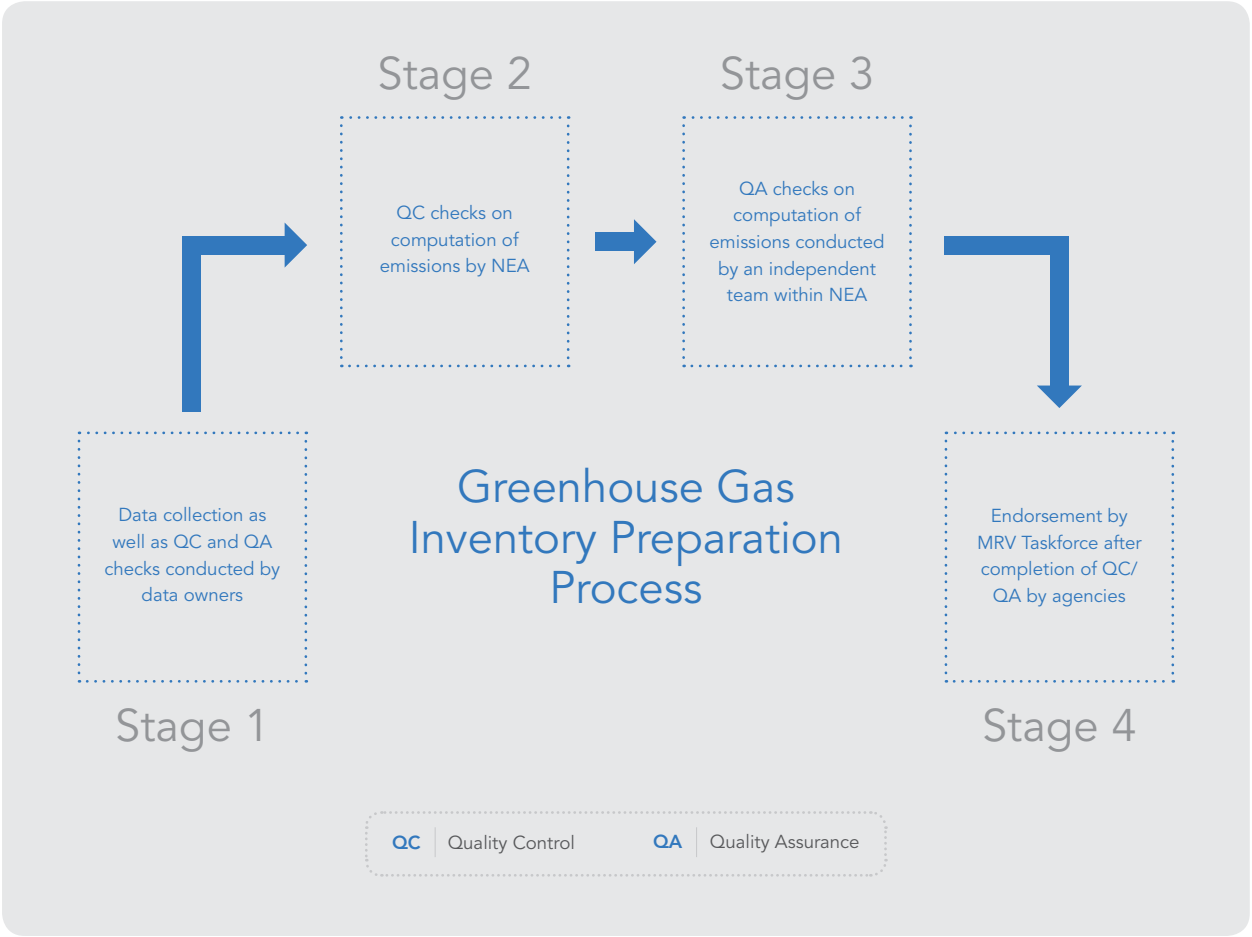


Time Series of Carbon and Energy Intensity



Preparation of the Greenhouse Gas Inventory

The preparation of the national greenhouse gas inventory is a multi-agency effort led by the National Environment Agency (NEA). An overview of the four-stage greenhouse gas inventory preparation process is shown below.



1) Quality Control and Quality Assurance for the Collection / Compilation of Data

Data required for the national greenhouse gas inventory are collected / compiled through legislation and surveys administered by the various government agencies (data owners). The sources of data for the national greenhouse gas inventory are as follows:

Sources of Data for Greenhouse Gas Inventory		
IPCC Sector	**Type of Greenhouse Gas**	**Data Owner**
Energy		
Electricity Generation	CO_2 , CH_4 , N_2O	Energy Market Authority
Industries		National Environment Agency Energy Market Authority
Land Transport		National Environment Agency Energy Market Authority Land Transport Authority
Transport (marine craft)		Maritime and Port Authority of Singapore
Commercial		Department of Statistics
Residential		Department of Statistics
Industrial Processes	HFCs , PFCs , SF_6	National Environment Agency
Waste		
Waste Incineration[25]	CO_2 , N_2O	National Environment Agency
Wastewater Handling	CH_4, N_2O	PUB, Singapore's national water agency, Food and Agriculture Organization of the United Nations (FAO)

[25] According to the IPCC Guidelines, CO_2 and N_2O emissions from waste incineration are reported in the Energy sector.

QC for Data

The quality control checks conducted by the data owners are summarised below:

	QC Activity	Actions by Data Owner
Units	Check that parameter units are correctly recorded and that appropriate conversion factors are used	Analysed and verified data trends for potential unit or conversion errors.
Database	Check for transcription errors in data input and reference	Analysed data trends. Highlighted deviations and outliers and verified them for potential data input errors and reference coding errors.
	Check the integrity of database files	Verified data processed in the database against original data files to ensure consistency and data integrity.
	Check for consistency in data between source categories	Verified the data mapping tables and files used to ensure that mapping and data consistencies between different source categories are maintained. Data mapping tables adopt Singapore classification standards.
	Undertake completeness checks	Streamlined and aligned data sources used. Included new data streams where applicable.
	Check methodological and data changes resulting in recalculations	Re-processed updated data in the system and recompiled sub-totals and totals from the updated data. Analysed time series of totals to ensure data quality standards are achieved.
Compilation	Check that the movement of inventory data among processing steps is correct	Verified and checked sub-totals against totals when computing aggregated figures.
	Internal documentation	Conducted regular data compilation reviews and documented these processes.
Comparison	Compare estimates to previous estimates	Analysed time series of totals to ensure data quality standards are achieved.

QA for Data

Data collected are verified by an independent team within each agency, who are not involved in the data collection and compilation process. After these quality assurance checks, agencies will submit their quality control and quality assurance documentations together with their data to NEA for computation/conversion to greenhouse gas emissions.

2) Quality Control for the Computation of Emissions

Greenhouse gas emissions are computed by the greenhouse gas inventory team within NEA based on the data provided by agencies, activity data and emission factors. For example, CO_2 emissions were computed from fuel consumption data and emission factors using the Revised 1996 IPCC Guidelines.

Quality control checks for the computation of greenhouse gas emissions were developed based on the 2000 IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. The quality control checks on emissions computed from source data are verified by persons who are not involved in the emission computation. These procedures help to minimise human errors during inventory compilation, and ensure the production of complete, accurate and consistent inventories. The quality control procedures that were conducted by the greenhouse gas inventory team within NEA are summarised overleaf.

	QC Activity on Estimation of Emissions	Actions
Units	Check that parameter and emission units are correctly recorded and that appropriate conversion factors are used	Checked the congruence of units and conversion factors throughout the worksheets.
Database	Check for transcription errors in data input and reference	Verified data processed in the worksheets against original data files to check for transcription errors. Analysed data trends. Highlighted deviations and outliers and verified them for potential data input errors and reference coding errors.
	Check for consistency in data between source categories	Verified that the emission factors and conversion factors used throughout the inventory are consistent with those in the IPCC Guidelines where applicable. Verified that local factors are used consistently where applicable.
	Undertake completeness checks	Streamlined and aligned data sources used.
Calculations	Check that the movement of inventory data among processing steps is correct	Verified that the equations used for the computation are consistent with the IPCC Guidelines. Analysed data trends. Highlighted deviations and outliers and verified them for potential data input errors and reference coding errors.
	Internal documentation	Checked that the sources, methodologies, assumptions, emission factors and quality control procedures are documented. Conducted regular reviews of data sources, methodologies, assumptions and emission factors and documented these processes.
Comparison	Compare estimates to previous estimates	Analysed time series of totals. Highlighted and verified deviations for potential errors.

Key Category Analysis

A key category analysis is conducted for the greenhouse gas inventory to identify major sources of greenhouse gas emissions, so that the resources available for inventory preparation are prioritised for major sources of emissions (see preceding section). The analysis is performed for emission sources, in terms of CO_2-equivalent emissions. Disaggregation to lower levels was not considered necessary as it splits important aggregated categories into small sub-categories that are no longer key.

3) Quality Assurance for Computation of Emissions

The quality assurance procedures comprise checking of transcription of data between databases, verification of data, emission factors, conversion factors and equations, including checking of the congruence of totals and sub-totals.

The computed emissions are verified by an independent NEA team that is not involved in the computation of the greenhouse gas emissions. This quality assurance team conducts a review of the inventory compilation process. The review involves the verifying of methods, data, processes and assumptions for the preparation of the inventory and recommendation of areas for improvement as necessary. During the review, needs for institutional strengthening and capacity building are identified and planned for to improve future work on the national greenhouse gases inventory. Training is proposed as necessary for new and existing officers involved in the preparation of the national greenhouse gas inventory.

4) Endorsement

An inter-agency working committee (MRV Taskforce) will review the quality control and quality assurance procedures conducted by agencies; and endorse the national greenhouse gas inventory.

Future Enhancements for Greenhouse Gas Inventory Compilation

An emissions data monitoring and analysis system is being developed to facilitate the inventory compilation process. The system will be designed to receive input and activity data from different data sources, generate emissions estimates, facilitate quality control checks and provide the relevant government agencies with secure access to the emissions database. The system is expected to be introduced into the inventory production process over the next few years.

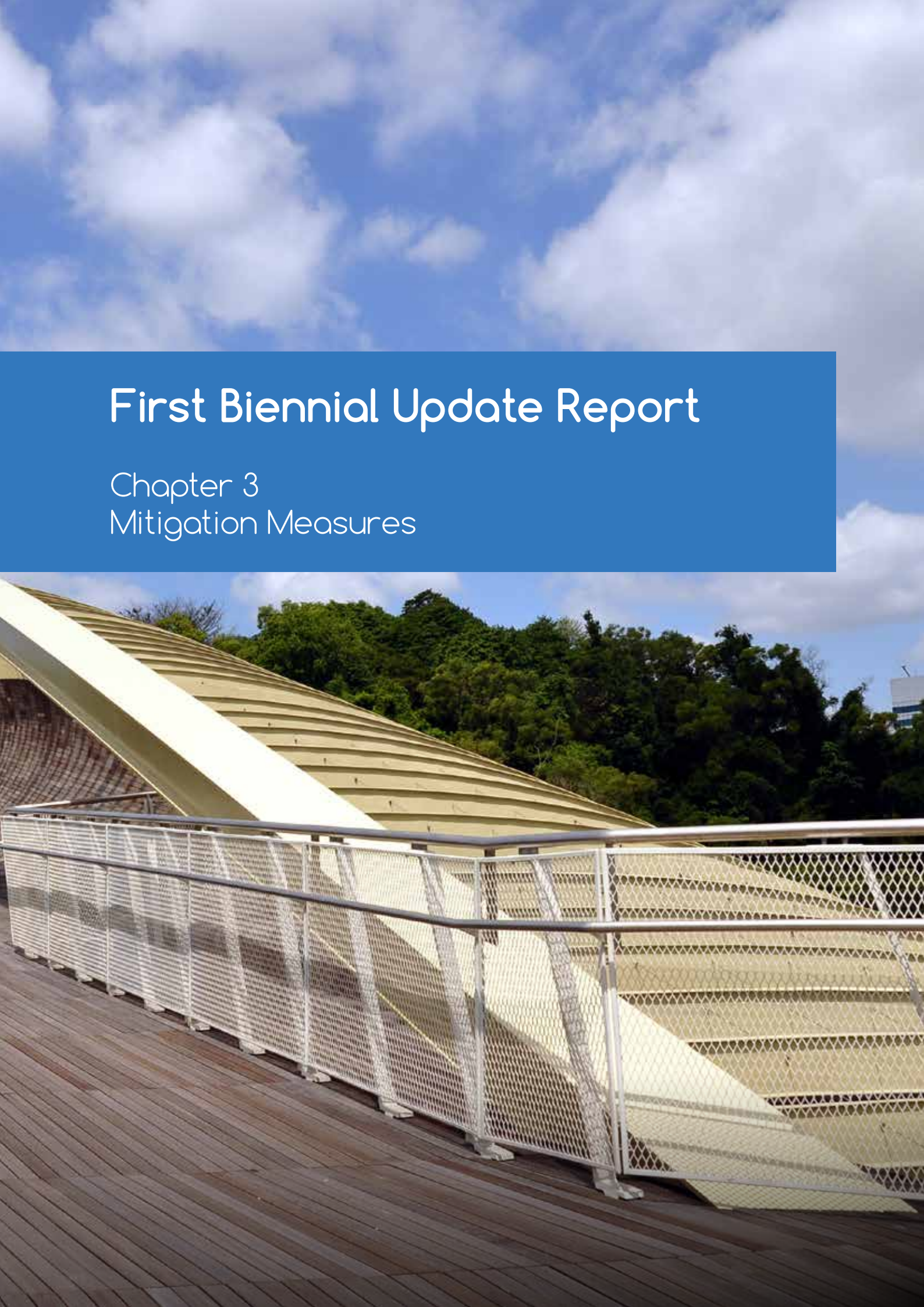
Automated quality control checks will be incorporated into the system. These include checks on the acceptable range of data input and factors, as well as percentage differences compared to emissions from previous years.

The system will be designed for efficient electronic data management and archiving of all data used in the estimation of emissions to ensure the continuity and security of the national greenhouse gas inventory. The data management functions of the system will include archival and storage of the emission estimates in previous National Communications, archival and storage of past activity data and emission factors, archival and storage of data source descriptions, methodology descriptions and reference materials, and one-stop integrated access to the documentation of data sources, methodology descriptions and reference materials.

Henderson Waves is Singapore's highest pedestrian bridge and is part of the Southern Ridges - a 10km stretch of green, open spaces that connect Mount Faber Park, Telok Blangah Hill Park, HortPark, Kent Ridge Park and Labrador Nature Reserve.

First Biennial Update Report

Chapter 3
Mitigation Measures



3 MITIGATION MEASURES

Introduction

Singapore has pledged to reduce emissions by 16% below 2020 business-as-usual[26] (BAU) levels if there is a legally binding global agreement in which all countries implement their commitments in good faith. Ahead of this, Singapore has embarked on policies and measures that will reduce our emissions by 7% to 11% below 2020 BAU levels. This is a challenging target, given our limited access to alternative energy solutions that could enable emissions reductions on a significant scale.

Singapore's Approach to Reducing Emissions

Energy is a strategic resource for Singapore as we are almost completely reliant on imports of oil and gas for our energy needs. Recognising that energy is a scarce resource, we price fuel and electricity according to supply and demand. We do not subsidise energy costs. By pricing energy correctly, we incentivise firms and households to make appropriate energy consumption choices. This minimises energy wastage and over-consumption, which contributes to reducing emissions.

Singapore has moved towards a cleaner fuel mix for electricity generation, switching from fuel oil to natural gas, which has lower carbon content per unit of electricity generated. However, there are limits to how much more emissions we can reduce by switching fuels, since natural gas already constitutes 84% of our fuel mix for electricity generation in 2012. While we continue to invest actively in research on clean energy technologies since the most direct way to reduce emissions is to cut down the use of fossil fuels, there are limits to the deployment of alternative or renewable energy sources in Singapore.

Given Singapore's limited access to renewable energy, energy efficiency is one of our core carbon emissions mitigation strategies. This will require our households and businesses to be more energy-conscious and make adjustments to their daily activities, choices and processes. In addition to reducing emissions, there will be cost savings as a result of reducing energy

[26] Projecting from 2005, Singapore's BAU emissions are expected to reach 77.2 million tonnes (MT) in 2020.

consumption. The Singapore Government will continue to raise awareness and build capabilities to improve energy efficiency across the sectors. A major part of this effort involves addressing sector-specific barriers using incentives or regulatory measures where appropriate.

Measures to Reduce Emissions

Measure 1: Shifting to Cleaner Energy Sources

We have switched from fuel oil to natural gas, with the proportion of Singapore's electricity generated by natural gas rising from 26% in 2001 to 84% in 2012. The grid emission factor of the power system has improved in tandem. Today, Singapore ranks among the countries with the highest percentage use of natural gas for electricity generation.

As a result of this switch from fuel oil to natural gas, Singapore has been reliant on natural gas piped from Malaysia and Indonesia for power generation. To ensure a resilient and more diverse supply of natural gas, the Singapore Government has built a liquefied natural gas (LNG) terminal that will allow us to import LNG from global gas markets. Having access to both LNG and piped natural gas will increase the share of clean natural gas in our fuel mix further.

We are exploring ways to increase our use of solar energy. Among the renewable energy options, solar energy presents the most viable option for Singapore. While the amount of solar energy harnessed in Singapore is still small, its deployment has been growing steadily. For solar energy to proliferate, consumers ultimately have to find it cost-competitive vis-à-vis the electricity they can buy from the grid. Notwithstanding the nascent deployment of solar energy in Singapore, we are actively investing in R&D and testbedding to improve the efficiency and lower the prices of solar technologies for adoption on a larger scale.

To facilitate this, the Economic Development Board (EDB) has launched solar capability building schemes such as the Solar Capability Scheme (SCS) and Clean Energy Research Testbedding (CERT), as well as the SolarNova programme which aims to accelerate solar deployment through promotion and aggregation of solar demand for the public sector. Overall, the government hopes to increase solar deployment to 350 megawatt-peak (MWp) by 2020.

To understand how available solar technology can be adopted for local conditions, the Housing & Development Board (HDB) is conducting large-scale solar test beds over a five-year period. In addition, HDB is studying new business models for solar power. For example, under a solar leasing model, the town council leases solar photovoltaic (PV) systems from private companies, which will own, design, finance, install, operate and maintain the solar PV systems. The town council will then pay the company for the solar power consumed at a rate that is equal to or lower than the retail electricity tariff rate. HDB has expanded the solar leasing scheme in September 2013 to more precincts, which will bring the total number of HDB blocks deployed with solar PV

panels to 176, generating up to 9.5 gigawatt-hour (GWh) of electricity annually by 2013. PUB, Singapore's national water agency, and EDB will be conducting a test-bedding project to explore floating solar PV on reservoir surfaces for possible deployment in the future.

Solar panels at Punggol Housing & Development Board (HDB) blocks.

In addition, the Energy Market Authority (EMA) has made various enhancements to the regulatory framework for intermittent generation sources, such as solar energy. Our aim is to put in place a framework which facilitates greater entry of intermittent sources, while maintaining power system stability.

By the end of 2012, there were about 10MWp of solar PV installations in Singapore, including projects at Resorts World Sentosa, Applied Materials' Changi North manufacturing plant, the Building and Construction Authority's (BCA) Zero Energy Building, and City Developments Limited's 7 & 9 Tampines Grande.

We are on track towards achieving 4.00 million tonnes (MT) of CO_2eq abatement from these measures to shift Singapore to cleaner energy sources by 2020, with an estimated 2.50MT of CO_2eq abatement in 2012.

Measure 2: Improving Industrial Energy Efficiency

As industry is the largest energy-consuming sector in Singapore, improving industrial energy efficiency is a key plank in our efforts to reduce emissions. In 2010, our economy-wide energy intensity was 55.3ktoe/S$ billion. This improvement over our 2000 economy-wide energy intensity of 72.7ktoe/S$ billion has partly been achieved with the help of schemes introduced by the Government to overcome market barriers, such as limited capital, split incentives, bounded rationality and lack of information, and to promote the widespread adoption of energy efficient practices.

The Singapore Government has committed more than S$100 million thus far to encourage the industry to adopt energy efficient technologies through grants, private sector financing schemes and tax incentives. We have also supported the development of expertise in the manufacturing sector through funding energy efficiency studies and national schemes to build energy efficiency capabilities.

Examples of these schemes include the Grant for Energy Efficiency Technologies (GREET), which helps companies reduce the initial capital outlay for energy efficiency investments, and the Energy Efficiency Improvement Assistance Scheme (EASe), which provides support for the conduct of energy assessments to identify potential areas for energy efficiency improvements. A pilot energy efficiency financing scheme was launched in 2013 to further address the market barrier of high upfront costs of energy efficiency investments.

Overall, we expect to achieve 1.15MT of CO_2eq abatement from these energy efficiency measures by 2020, with an estimated 0.51MT of CO_2eq abatement in 2012.

Measure 3: Greening Buildings

As a highly urbanised island state, the greening of buildings is an important part of Singapore's mitigation strategy. To address barriers to energy efficiency adoption in buildings such as limited capital and split incentives between building developers and owners, the Singapore Government implemented the Green Building Masterplan, and launched the BCA Green Mark Scheme, a national yardstick designed specifically for buildings in the tropics.

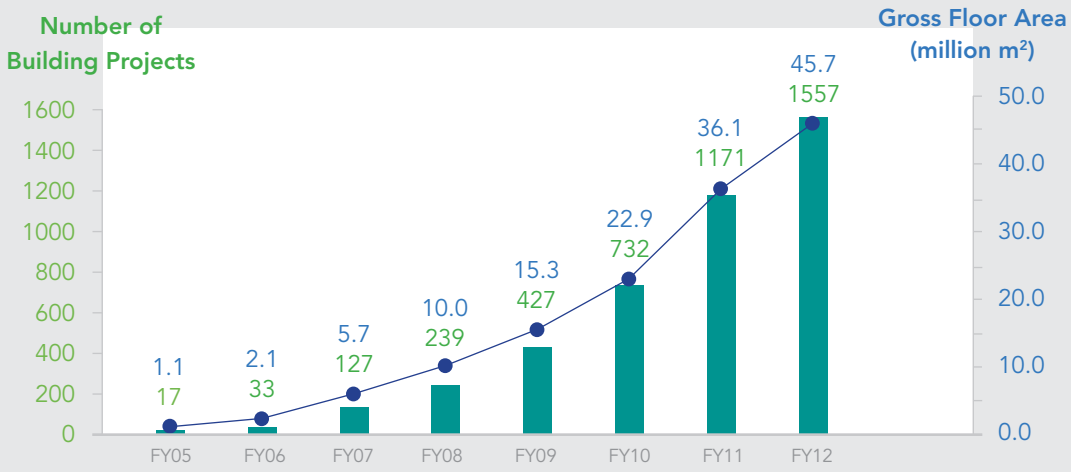
The first Green Building Masterplan was launched in 2006 and focused on greening new buildings while the second was launched in 2009 and focused on the greening of existing buildings. The second Masterplan also gave more prominence to R&D, and greater emphasis on profiling Singapore as an international leader in green building capability. The third Masterplan, launched in 2014, focused on engaging tenants and occupants to drive energy consumption behavioural change towards greater efficiency and on improving their well-being.

To drive the Green Building Movement, the Singapore Government has put forth both regulations and incentives. Developers and owners of new buildings or existing buildings undergoing major retrofitting works with a gross floor area of more than 2,000 square meters are required to achieve minimum Green Mark standards. New building projects in key strategic areas such as Marina Bay, Downtown Core and Jurong Lake District are required to meet even higher standards. Existing office, hotel and retail buildings are required to submit building information and energy consumption data annually for energy benchmarking purposes. In addition, commercial buildings with gross floor area of more than 15,000 square meters are required to achieve minimum Green Mark standards when a cooling system is installed or retrofitted, and also carry out three-yearly energy audit on building cooling systems. The regulations are complemented with incentives and financing schemes, such as the Green Mark Gross Floor Area (GMGFA) Incentive Scheme, S$100 million Green Mark Incentive Scheme for Existing Building (GMIS-EB) and Building Retrofit Energy Efficiency Financing (BREEF) scheme, for developers to achieve higher-tiered Green Mark ratings, and to assist building owners in financing the high upfront retrofitting cost.

To promote sustainable building practices in the larger Southeast Asia region, the BCA of Singapore has been working closely with the UN Environment Programme Sustainable Building and Climate Initiative (UNEP-SBCI). BCA also established a Centre for Sustainable Buildings that will assist countries in the region to develop tools and train them to propagate sustainable building solutions.

The mitigation measures in the building sector are projected to achieve 1.21MT of CO_2eq abatement by 2020, with an estimated 0.15MT of CO_2eq abatement in 2012.

Green Mark Building Projects in Singapore (Cumulative)



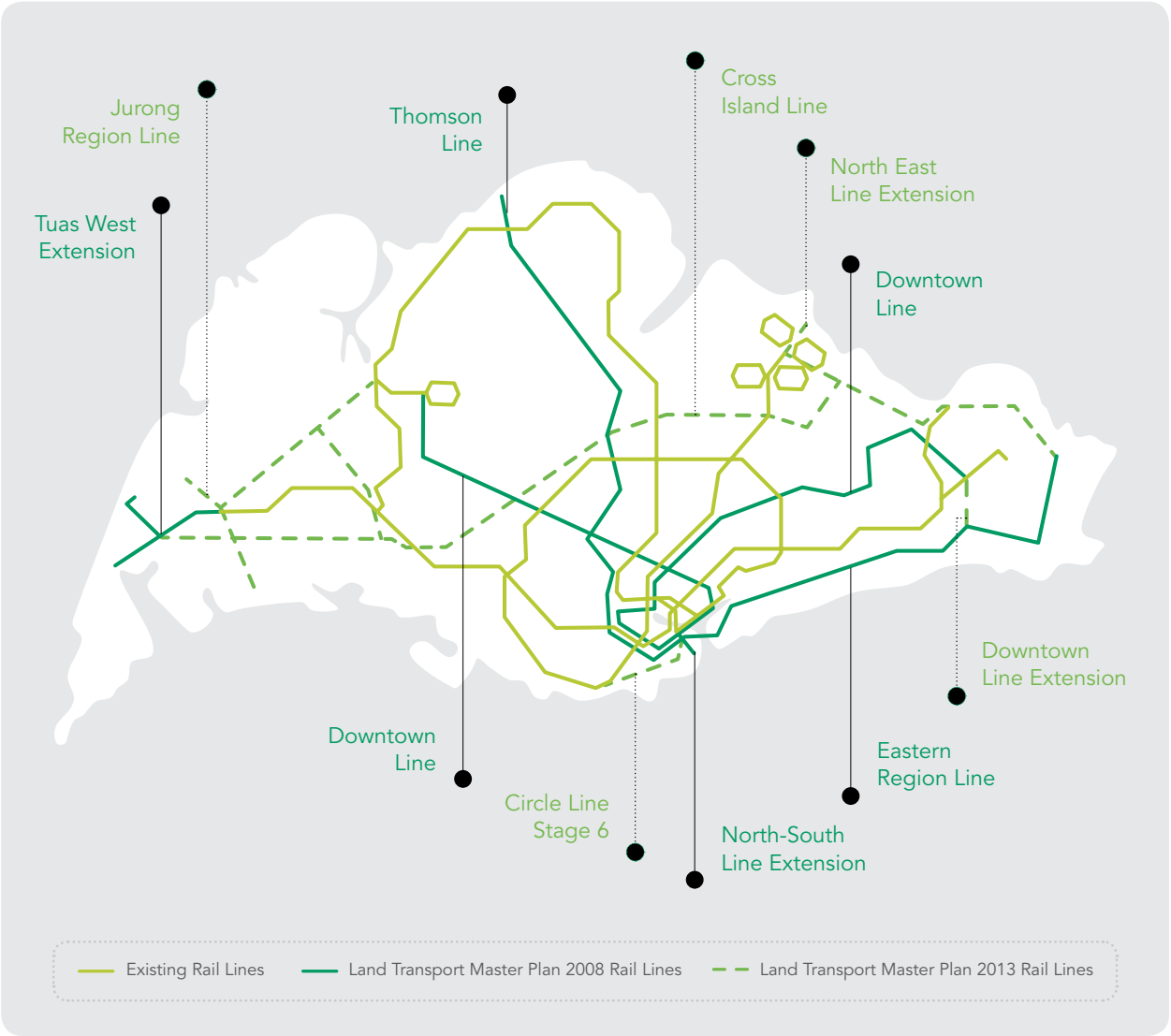
Note: The full period of each Financial Year (FY) used for the chart above is 1 April to 31 March.

As the Building and Construction Authority (BCA)'s flagship R&D project under its Green Building Masterplan, an existing building at the BCA Academy was retrofitted into a Zero-Energy Building which functions as a test-bedding centre for Green Building Technologies.

Measure 4: Shifting Travel Demand to Low-Emission Modes and Reducing Vehicular Emissions

Public transport is the most efficient and the most environmentally sustainable mode of transport. To reduce emissions from increasing transport demand, the Singapore Government targets to achieve a 70% public transport modal share during the morning peak hours by 2020, up from 59% in 2008. Under the refreshed Land Transport Master Plan 2013, the Government is targeting to achieve a 75% public transport modal share during both the morning and evening peak hours by 2030.

To encourage the use of public transport, the length of the rail network in Singapore will be significantly increased from 178km in 2012 to about 280km by around 2020 and to about 360km by 2030. The capacity of the public bus fleet will also increase by 35% from 2012 to 2017 and 80 new bus services will be introduced to enhance the expanded bus network connectivity under the expanded Bus Service Enhancement Programme (BSEP).



By improving the attractiveness of public transport, the Government aims to reduce reliance on private transport. Ownership and usage of private cars will continue to be managed through various fees and taxes to reflect the competing needs for our scarce land. Prospective car owners are required to bid and pay for limited Certificates of Entitlement controlled in accordance with the sustainable vehicle population growth rate. Usage of cars is managed using Electronic Road Pricing, where vehicles have to pay a charge for entering congested roads during specific periods.

Additionally, the Singapore Government is undertaking efforts to lower emissions from the various modes of travel. For example, the Carbon Emissions-based Vehicle Scheme was introduced in 2013. A rebate is given to low-emission cars and taxis while a surcharge is imposed on high-emission cars and taxis. The Fuel Economy Labelling Scheme also helps to encourage the use of greener vehicles. Under the scheme, all cars and light goods vehicles that are displayed for sale must be affixed with a fuel economy label that provides information on their fuel consumption. A study on reducing emissions from buses is also being undertaken in the form of a trial on diesel hybrid buses.

Lastly, the Singapore Government aims to facilitate walking and cycling as ways to encourage the use of public transport and as alternative modes of transport, thereby reducing our carbon footprint. The Government is building 200km of sheltered walkways by 2018 under the Walk2Ride programme to improve the walking experience of commuters when they walk to MRT (Mass Rapid Transit) stations, bus interchanges and some bus stops. The Government is also building a comprehensive network of cycling paths across the island that will reach over 700km in 15 years time. As many commuters also cycle to MRT stations, more bicycle parking facilities are also being added at MRT stations.

Overall, the mitigation measures in the transport sector are projected to achieve 1.16MT of CO_2eq abatement in 2020, with an estimated 0.20MT of CO_2eq abatement in 2012.

Measure 5: Improving Energy Performance Standards of Household Appliances and Promoting Energy Efficiency to Households

The households sector accounts for about 16% of the total electricity consumption in Singapore. To improve energy efficiency in homes, the Singapore Government implemented the Mandatory Energy Labelling Scheme (MELS) for household appliances in 2008. Registrable goods must carry the energy label under the Energy Conservation Act. To date, energy labelling has been mandated for air-conditioners, refrigerators, clothes dryers, and more recently in 2014, televisions. MELS furnishes consumers with information on the energy performance of different appliances, which empowers households to make better purchasing decisions. In September 2014, the energy tick ratings on energy labels were re-calibrated to help consumers better differentiate the energy efficiency of various models and to encourage appliance suppliers to bring in even more energy efficient models. The energy label was also enhanced with information on the products' estimated annual energy running cost and consumption.

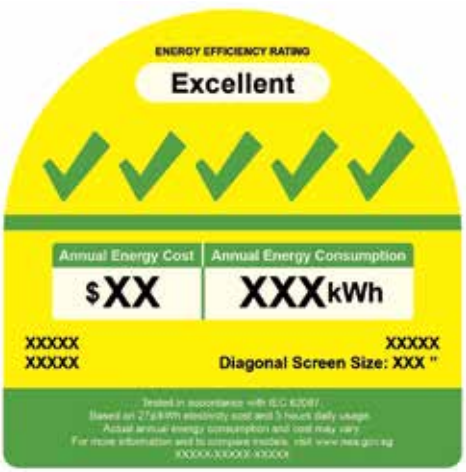
Regulations on Minimum Energy Performance Standards (MEPS) were introduced for refrigerators and air conditioners in 2011. MEPS for air-conditioners and refrigerators were raised in 2013. MEPS remove the most inefficient models that fall short of specified minimum energy efficiency levels from the market.

The 10% Energy Challenge campaign was launched in 2008 to challenge households to reduce their energy use by 10% or more by practising simple energy-saving habits. Initiatives under the 10% Energy Challenge include media publicity, community outreach events, energy-saving contests in schools and at national level, energy efficiency appliance fairs, and a Voluntary Agreement with retailers and suppliers to promote more energy efficient home appliances.

Mandatory Energy Labelling Scheme.

In response to the growing use of smart phones, the Singapore Government rolled out the "Home Energy Auditor (HEA)" and "Life Cycle Cost Calculator (LCC)" mobile applications in 2012. The HEA application allows households to conduct their own energy audits at home, while the LCC application helps consumers compare the life cycle costs of different models of air-conditioners, refrigerators and clothes dryers easily and make informed purchasing decisions.

The mitigation measures in the households sector are projected to achieve 0.71MT to 1.07MT of CO_2eq abatement by 2020, with an estimated 0.05MT of CO_2eq abatement achieved in 2012.



Energy Label.

Measure 6: Reducing Emissions from Waste and Wastewater Treatment

The Singapore Government is also looking to reduce emissions from the waste and wastewater sectors. Apart from incinerating our waste and wastewater sludge which reduces methane emissions from landfills, we also intend to increase our recycling rate to 70% by 2030 and are exploring more energy efficient desalination technologies.

We project the mitigation measures in the waste and water sector to achieve 0.15MT of CO_2eq abatement by 2020, with an estimated 0.06MT of CO_2eq abatement in 2012.

International Market Mechanisms

As a non-Annex I Party, Singapore is eligible to participate in the Clean Development Mechanism (CDM) of the Kyoto Protocol which allows greenhouse gas emission reductions from registered projects implemented in non-Annex I Party to earn certified emission reductions (CER) credits, which could be used to offset emissions of Annex I Parties.

As of October 2014, Singapore has 6 registered CDM projects. The estimated emission reductions from these 6 projects is about 473kt CO_2eq annually.

Registered	Title	Methodology	Estimated Emission Reductions (tonnes CO_2eq per annum)
18 Nov 08	Thermal energy recovery for new applications at No.5 Sungei Kadut Street 6 by Bee Joo Industries Pte Ltd, Singapore	AMS-I.C. ver. 12	15205
13 Sep 10	Dehydration and incineration of sewage sludge in Singapore	AM0025 ver. 11	101577
12 Dec 12	Kim Hock Biomass Energy and Wood Recycling Plant	AMS-I.C. ver. 19	31360
31 Dec 12	Chew's biogas plant for treatment of poultry waste and recovery of biogas for electricity generation in Singapore	AMS-III.D. ver. 18 AMS-I.F. ver. 2	31837
5 Jun 14	Demand side energy efficiency measures in building lighting systems	AMS-II.C. ver. 14	6291
14 Jul 14	Grid connected electricity generation plant using natural gas at Jurong Island in Singapore	AM0029 ver. 3	286755

Domestic Measurement, Reporting and Verification

With regard to domestic measurement, reporting and verification (MRV) of information on Singapore's mitigation actions, sectoral lead agencies such as the Ministry of the Environment and Water Resources, the Ministry of Foreign Affairs, the Ministry of National Development, the Ministry of Transport, the Ministry of Trade and Industry, the National Climate Change Secretariat, the Building and Construction Authority, the Economic Development Board, the Energy Market Authority, the Land Transport Authority, the Maritime and Port Authority of Singapore, the National Environment Agency, the National Parks Board and PUB - Singapore's national water agency, monitor, measure and document the progress of implementation of the mitigation actions under their purview. This information is consolidated by the Long Term Emissions and Mitigation Working Group secretariat annually. The accuracy of the information reported will be verified by the sectoral lead agency through internal checks. The Long Term Emissions and Mitigation Working Group will then assess and determine whether the various mitigation measures have been implemented and that Singapore is on track to meet our mitigation pledge and objectives.

List of Mitigation Measures

Table 1 | Shifting to Cleaner Energy Sources

Mitigation Action	Objectives	Description	Progress of Implementation/Steps taken or envisaged to achieve action	Nature of Action	2020 Quantitative Goal (MT)	Methodologies and Assumptions	Gas Coverage	Progress Indicators	Results Achieved
Fuel mix switch away from fuel oil	To switch fuel mix away from fuel oil, towards natural gas for power generation.	Facilitating the utilisation of natural gas for power generation. Abatement is expected from an increase in the share of natural gas in the generation mix from approximately 70% in the BAU case to 90% by 2020.	**Ongoing** Since 2005, the power generation industry has begun repowering to natural gas, which includes the establishment of an LNG terminal and introduction of LNG vesting.	Infrastructure Development	4.0	Natural gas is expected to form 90% of Singapore's fuel mix for power generation in year 2020 and is the basis of the projected abatement in 2020. The carbon abatement achieved by this measure is estimated based on the amount of fuel oil displaced by cleaner natural gas for power generation.	CO_2	Fuel Mix.	Increase in the share of natural gas to 84% in 2012. Estimated abatement achieved in 2012: 2.5MT
Solar installation from existing schemes	To facilitate the adoption of solar Photovoltaics (PVs).	Encouraging more solar test-bedding and research.	**Ongoing** The whole of government effort to facilitate solar adoption includes capability development, such as HDB's solar capability building programme for public housing as well as EDB's incentive schemes for R&D and test-beds, such as the Solar Capability Scheme (SCS), Clean Energy Research and Test-bedding (CERT) scheme and floating PV project.	Incentive, Technology	0.0085-0.0135	The carbon abatement achieved by this measure is based on the emissions from Combined Cycle Gas Turbines (CCGTs) that would result from generating the amount of electricity displaced by solar.	CO_2	Solar Capacity.	Estimated abatement achieved in 2012: 0.0034MT

Table 2 | Improving Industry Energy Efficiency and Promoting Use of Cleaner Fuels

Mitigation Action	Objectives	Description	Progress of Implementation/Steps taken or envisaged to achieve action	Nature of Action	2020 Quantitative Goal (MT)	Methodologies and Assumptions	Gas Coverage	Progress Indicators	Results Achieved
Cogeneration plants	To encourage investment in cogeneration plants.	Encouraging cogeneration plant investments, which will reduce carbon emissions through increasing energy efficiency in electricity and steam generation.	**Ongoing** One cogeneration plant is currently under construction with an estimated 130ktpa of abatement. 2 to 3 more plants are expected to be constructed in the period 2015-2020.	Incentive	0.67-0.73	0.67-0.73MT of carbon mitigation by 2020 are assumed to be delivered by 3 to 4 cogeneration plants in the petroleum and petrochemical sector. Carbon mitigation achieved per cogeneration plant is based on technical estimates and information provided by companies.	CO_2	Number of cogeneration plants, total funding given out, abatement achieved calculated through data collection/ audits.	Estimated abatement achieved in 2012: 0.13MT
Promoting Manufacturing Energy Efficiency	To encourage Energy Efficiency (EE) and consequently reduce emissions from the manufacturing sector.	Encouraging EE retrofits in the manufacturing sector through incentives, and conducting a pilot on private sector financing of EE projects.	**Ongoing** 313ktpa of carbon abatement has been achieved through the Grant for Energy Efficient Technologies (GREET), tax incentives, and other supporting schemes such as the Energy Efficiency Improvement Assistance (EASe) and Design for Efficiency (DfE) schemes.	Incentive	0.313-0.40	Abatement assumed to be 1% above BAU levels for a period of 3 years for 90% of manufacturing sector. Abatement arising from GREET and tax incentives will be audited by Professional Engineers or Qualified Energy Services Specialists shortly after the commissioning period. All other incentives verified by company voluntary reporting.	CO_2	Total funding given out, abatement achieved calculated through data collection/ audits.	Estimated abatement achieved in 2012: 0.31MT
Fuel switching in industry	To encourage fuel switching in third-party utility providers.	Encouraging third-party utility providers to switch to cleaner fuel for steam generation.	**Completed** 70ktpa carbon abatement has been achieved with the investment of two woodchip boilers totalling 60 tons per hour of steam production capacity.	Incentive	0.07	Abatement calculated based on company feedback and announced publicly by company.	CO_2	Abatement achieved calculated through data collection/ audits.	Estimated abatement achieved in 2012: 0.07MT
Data Centre EE	To encourage EE and consequently reduce emissions from SG data centres.	Encouraging EE retrofits in data centres through incentives.	**Ongoing** Since 2012, investment allowances are being awarded to green Data Centres (DCs). The target of 15 DCs taking up the incentive by 2015 is expected to deliver up to 0.04MT of carbon abatement.	Incentive	Up to 0.04	Abatement calculated based on Power Usage Effectiveness (PUE) improvements. PUE is a measure of how efficiently a data centre uses its power and is the ratio of a data centre's total facility power need to that of all Information and Communications Technology (ICT) equipment.	CO_2	Power Usage Effectiveness of Data Centers.	Estimated abatement achieved in 2012: NIL

Table 3 | Greening Buildings

Mitigation Action	Objectives	Description	Progress of Implementation/Steps taken or envisaged to achieve action	Nature of Action	2020 Quantitative Goal (MT)	Methodologies and Assumptions	Gas Coverage	Progress Indicators	Results Achieved
Green Mark new buildings	To improve energy efficiency of new buildings.	Legislating new building owners to achieve minimum Green Mark (GM) standard and incentivising buildings to achieve GM rating beyond the minimum standard through the Green Mark Incentive Scheme for New Buildings. Developments in identified key strategic areas are required to achieve higher GM rating of Goldplus or Platinum.	**Ongoing** Since 2008, new building owners have been required by legislation to achieve minimum Green Mark (GM) standards. The four GM ratings are: Certified/ Gold/ Goldplus/ Platinum, differentiated by a set of criteria relating to green initiatives and energy savings of the building. In addition, stricter GM standards have been imposed in land sales conditions in certain areas, e.g. Marina Bay, Jurong Lake. The $20mil Green Mark Incentive Scheme and Green Mark Gross Floor Area Incentive Scheme have also been introduced to encourage greater efficiency in new buildings.	Legislation and Incentives	0.47	The target abatement is calculated by the difference between the emission values projected for BAU and emission values projected for 2020 with legislation for new buildings to achieve minimum Green Mark standards. Based on the new buildings built since the Act was in force, the legislation has resulted in 0.15MT of carbon abatement relative to the BAU case.	CO_2	Through electricity consumption and building information data conducted using the Building Energy Submission System (BESS).	Estimated abatement achieved in 2012: 0.15MT
Green Mark existing buildings	To improve energy efficiency of existing buildings.	Legislating existing building to improve the energy efficiency of their facilities when undergoing major retrofits to achieve minimum GM standards and incentivising buildings to achieve GM rating beyond the minimum standard through the Green Mark Incentive Scheme for Existing Buildings.	**Ongoing** Existing buildings are required by legislation to achieve minimum Green Mark (GM) standard when they undergo major retrofit. In addition, existing office, hotel and retail buildings are required to submit building energy consumption annually, and carry out three-yearly energy audit on building cooling systems. To incentivise further EE improvements in existing buildings, $100 million has been set aside to co-fund up to 50% (capped at $3mil) of EE investments for existing buildings and a Building Retrofit Energy Efficiency Financing (BREEF) scheme was also introduced to provide financing options to address the high upfront costs required.	Legislation and Incentives	0.40-1.08	The target abatement is calculated by the difference between the emission values projected for 2020 with Green Mark new buildings measures and the emission values projected for 2020 with legislation requiring all existing buildings that undergo major retrofit to comply with GM minimum standards.	CO_2	As above.	Estimated abatement achieved in 2012: Data not available at time of print

Table 4 | Shifting Travel Demand to Low-Emission Modes and Reducing Vehicular Emissions

Mitigation Action	Objectives	Description	Progress of Implementation/Steps taken or envisaged to achieve action	Nature of Action	2020 Quantitative Goal (MT)	Methodologies and Assumptions	Gas Coverage	Progress Indicators	Results Achieved
Increasing the public transport modal share	To increase usage of public transport, the most energy efficient mode of motorised travel.	Various infrastructural improvements such as expanding the rail and bus network, better planning (e.g. integrated transport hubs), bus priority measures; and managing travel demand as detailed in the Land Transport Master Plan 2013.	**Ongoing** The public transport modal share in 2020 is expected to improve from 55% in the BAU case to 70% in 2020 as a result of efforts to shift commuters towards public transport. These efforts include building new rail lines such as the Downtown Line, rolling out more buses on the roads via the Bus Service Enhancement Programme, building more integrated transport hubs, and expanding bus lanes and the Mandatory Give-Way to Buses scheme. The public transport modal share improved from 59% in 2008 to 63% in 2012.	Combination of infrastructure, regulations, incentives, technology and education	0.78	Mitigation impact achieved is calculated as the difference between emissions projected from the BAU scenario and the emissions from actual travel demand.	CO_2	Public transport modal share.	Estimated abatement achieved in 2012: 0.16MT
Promoting Off-Peak Cars/walking and cycling	To reduce reliance on cars as a means of transport.	Implementing the Off-Peak Car (OPC) scheme, and rolling out the Walk2Ride Programme and National Cycling Plan.	**Ongoing** The number of off-peak cars has increased from 3.0% in 2005 to 7.3% of total car population in 2012. LTA will construct 210km of intra-town cycling paths in HDB towns and Marina Bay by 2020 and link this with the Park Connector Network to create an island-wide network of 700km in 2030. LTA will construct 200km of sheltered walkways by 2018 to improve the walking experience of commuters taking public transport.	Combination of infrastructure, incentives and education	0.16-0.20	Abatement calculated based on the increase in OPCs and the difference between the average carbon emissions of a normal car compared to those of an OPC.	CO_2	OPC take-up rate.	Estimated abatement achieved in 2012: 0.03MT
Car/Taxi fuel efficiency – CEVS	To encourage the take-up of more energy-efficient vehicles.	Implementing the mandatory Fuel Economy Labelling Scheme (FELS) and the Carbon Emissions-based Vehicle Scheme (CEVS).	**Ongoing** CEVS rebates were implemented from Jan 2013 and the surcharges from Jul 2013. The scheme will be reviewed before Jun 2015. 55% of cars registered in 2013 enjoyed rebates, compared to 41% in 2012 had the scheme been in place then.	Legislation and Incentive	0.10	Abatement calculated based on increased quantity of cars purchased in each lower-carbon band compared to historical rates and the average carbon emission reduction between CEVS-bands.	CO_2	Increase in registration of cars in low-carbon bands and reduction in registration of cars in the high-carbon bands.	Estimated abatement achieved in 2012: NIL
Green Technology Programme (GTP)	To encourage local maritime companies to develop and adopt green technologies.	Providing grants to Singapore-registered companies engaging in maritime related businesses for the development and adoption of green technological solutions.	**Ongoing** Projects approved by the Green Technology Programme have been ongoing since 2012.	Incentive	0.10 (subject to review based on take-up rates of projects)	Abatement will be calculated using specific information from each project and monitored for take-up rates.	CO_2, SOx and NOx	GTP take-up rate.	Estimated abatement achieved in 2012: 0.0064MT

Table 5 | Improving Energy Performance Standards of Household Appliances and Promoting Energy Efficiency to Households

Mitigation Action	Objectives	Description	Progress of Implementation/Steps taken or envisaged to achieve action	Nature of Action	2020 Quantitative Goal (MT)	Methodologies and Assumptions	Gas Coverage	Progress Indicators	Results Achieved
Minimum Energy Performance Standards (MEPS) for household appliances - air-cons, fridges, lighting	To improve the overall energy efficiency of appliances in the market.	Disallowing the supply of inefficient appliances that fall short of specified minimum EE levels.	**Ongoing** MEPS for air-cons and fridges were implemented in September 2011 and tightened in September 2013. MEPS for general lighting are planned for implementation in 2015. Further tightening of MEPS for air-cons and fridges is planned for review in 2015.	Legislation	0.71–0.79	Abatement in 2012 was calculated by comparing the actual sales data of household appliances by tick-rating efficiency, against the projected sales data in the BAU scenario.	CO_2	Annual sales data of household appliances.	Estimated abatement achieved in 2012: 0.05 MT* *MEPS commenced in 2011.
Promotion of energy efficiency to households	To promote energy efficiency to households.	Promoting energy efficiency to households by improving awareness.	**Ongoing** Mandatory Energy Labelling Scheme (MELS) for air-con and fridge were introduced in 2008. MELS was extended to clothes dryers and televisions in 2009 and 2014 respectively. MELS will be extended to general lighting in 2015. EE awareness programmes (e.g. media publicity, energy-saving contests, EE roadshows) were rolled out between 2008 and 2012.	Promotion	0–0.28				

Table 6 | Reducing Emissions from Waste and Wastewater Treatment

Mitigation Action	Objectives	Description	Progress of Implementation/Steps taken or envisaged to achieve action	Nature of Action	2020 Quantitative Goal (MT)	Methodologies and Assumptions	Gas Coverage	Progress Indicators	Results Achieved
Wastewater sludge disposal by incineration	To reduce methane gas emissions from wastewater sludge.	Incinerating wastewater sludge, a by-product of Water Reclamation Plants, which would otherwise be disposed off at landfills.	**Ongoing** Since 2009, ECO Special Waste Management and Sumitomo Mitsui Banking Corporation have been contracted to perform sludge incineration.	Infrastructure	0.10	Assumptions are referenced from IPCC methodology "Tool to determine the methane emissions avoided from disposal of waste at a solid waste disposal site", and abatement is calculated from the total amount of sludge incinerated.	CH_4	Amount of sludge incinerated.	Estimated abatement achieved in 2012: 0.06 MT
Increase overall recycling rate	To increase the overall recycling rate to 65% by 2020.	Mandatory waste reporting and submission of waste reduction plan for large commercial premises, starting with large hotels and shopping malls to be implemented in 2014.	Mandatory waste reporting and the submission of waste reduction plan have been implemented for large hotels and shopping malls in 2014.	Legislation	0.05	Emissions and abatement will be calculated using the amount of waste disposed, the proportion of incineration over disposed at landfill, and waste recycling rates.	CO_2, N_2O	Recycling rate.	Estimated abatement achieved in 2012: NIL
		Right waste disposal pricing.	Currently under evaluation.	Market Based Instrument					

ANNEX TO BIENNIAL UPDATE REPORT

2010 Greenhouse Gas Inventory Worksheets
Greenhouse Gas Summary Tables for 2000 and 1994

2010 GREENHOUSE GAS INVENTORY

1A1 - CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)

Country: Singapore
Year: 2010

		STEP 1	STEP 2		STEP 3		
		A	B	C	D	E	F
		Consumption	Conversion Factor	Consumption [C=AxB]	Carbon Emission Factor	Carbon Content [E=CxD]	Carbon Content [F=E/1000]
Fuel Types	Unit	Actual (Quantity)	1996 IPCC (TJ/Unit)	Actual (TJ)	1996 IPCC (t C/TJ)	(t C)	(Gg C)
Energy and Transformation Industry							
Liquid Fuels							
Crude Oil	kt						
Ethane	kt						
Gas/Diesel Oil	kt	139.03	43.33	6024.30	20.20	121690.86	121.69
Gasoline	kt						
Jet Kerosene	kt						
Liquefied Petroleum Gases (LPG)	kt						
Lubricants	kt						
Naphtha	kt						
Natural Gas Liquids	kt						
Orimulsion	kt						
Other Kerosene	kt						
Petroleum Coke	kt						
Refinery Gas	kt						
Residual Fuel Oil	kt	1822.84	40.19	73260.10	21.10	1545788.12	1545788.12
Solid Fuels							
Anthracite	kt						
Blast Furnace Gas	kt						
Brown Coal Briquettes	kt						
Coke Oven Coke	kt						
Coke Oven Gas	kt						
Coking Coal	kt						
Gas Coke	kt						
Gas Works Gas	GWh						
Lignite	kt						
Other Bituminous Coal	kt						
Patent Fuel	kt						
Peat	kt						
Sub-Bituminous Coal	kt						
Natural Gas							
Natural Gas (Dry)	ktoe	5799.62	41.868	242818.49	15.30	3715122.90	3715.12
Other Fossil-Based Fuels							
Industrial Waste	kt						
Municipal Solid Waste	kt						
Memo Items							
Gaseous Biomass	kt						
Liquid Biomass	kt						

NOTE

1. Data on international bunker fuels have been reported in a separate memo to the UNFCCC as emissions from such bunker fuels are to be excluded from the national greenhouse gas totals.
2. IPCC default factors are used except for the Emission Factor for Gas Works Gas (15.2) which is a country-specific factor.
3. According to the IPCC Guidelines, autoproducers are classified under the Industry Sector.
4. Natural Gas data which is obtained from EMA in ktoe is multiplied by 0.9 to correct the gross calorific value (GCV) into the net calorific value (NCV), in line with the Revised 1996 IPCC Guidelines.
5. Transformation losses from the production of Gas Works Gas are included under the fuel type "Natural Gas" in the Industry Sector.
6. Emissions from the combustion of Synthesis Gas are included under the fuel type "Refinery Gas" in the Industry Sector.
7. Gas Works Gas was mainly produced from Natural Gas in Singapore.

1A1 - CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)
Country: Singapore
Year: 2010

		STEP 4			STEP 5		STEP 6
		G	H	I	J	K	L
		Fraction of Carbon Stored	Carbon Stored [H=FxG]	Net Carbon Emissions [I=F-H]	Fraction of Carbon Oxidised	Actual Carbon Emissions [K=IxJ]	Actual CO_2 Emissions [L=Kx44/12]
Fuel Types	Unit	1996 IPCC			1996 IPCC		Actual
			(Gg C)	(Gg C)		(Gg C)	(Gg CO_2)
Energy and Transformation Industry							**19,451.02**
Liquid Fuels							
Crude Oil	kt						
Ethane	kt						
Gas/Diesel Oil	kt	0	0	121.69	0.99	120.47	441.74
Gasoline	kt						
Jet Kerosene	kt						
Liquefied Petroleum Gases (LPG)	kt						
Lubricants	kt						
Naphtha	kt						
Natural Gas Liquids	kt						
Orimulsion	kt						
Other Kerosene	kt						
Petroleum Coke	kt						
Refinery Gas	kt						
Residual Fuel Oil	kt	0	0	1545.79	0.99	1530.33	5611.21
Solid Fuels							
Anthracite	kt						
Blast Furnace Gas	kt						
Brown Coal Briquettes	kt						
Coke Oven Coke	kt						
Coke Oven Gas	kt						
Coking Coal	kt						
Gas Coke	kt						
Gas Works Gas	GWh						
Lignite	kt						
Other Bituminous Coal	kt						
Patent Fuel	kt						
Peat	kt						
Sub-Bituminous Coal	kt						
Natural Gas							
Natural Gas (Dry)	ktoe	0	0	3715.12	0.995	3696.55	13554.01
Other Fossil-Based Fuels							
Industrial Waste	kt						
Municipal Solid Waste	kt						
Memo Items							
Gaseous Biomass	kt						
Liquid Biomass	kt						

1A2 - CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)
Country: Singapore
Year: 2010

		STEP 1	STEP 2		STEP 3		
		A	B	C	D	E	F
		Consumption	Conversion Factor	Consumption [C=AxB]	Carbon Emission Factor	Carbon Content [E=CxD]	Carbon Content [F=E/1000]
Fuel Types	Unit	Actual	1996 IPCC	Actual	1996 IPCC		
		(Quantity)	(TJ/Unit)	(TJ)	(t C/TJ)	(t C)	(Gg C)
Industry							
Liquid Fuels							
Crude Oil	kt						
Ethane	kt						
Gas/Diesel Oil	kt	507.98	43.33	22010.69	20.20	444615.87	444.62
Gasoline	kt						
Jet Kerosene	kt						
Liquefied Petroleum Gases (LPG)	kt	28.00	47.31	1324.68	17.20	22784.50	22.78
Lubricants	kt						
Naphtha	kt						
Natural Gas Liquids	kt						
Orimulsion	kt						
Other Kerosene	kt						
Petroleum Coke	kt	73.20	31.00	2269.20	27.50	62403.00	62.40
Refinery Gas	kt	2791.47	48.15	134409.24	18.20	2446248.22	2446.25
Residual Fuel Oil	kt	1079.76	40.19	43395.43	21.10	915643.65	915.64
Solid Fuels							
Anthracite	kt						
Blast Furnace Gas	kt						
Brown Coal Briquettes	kt						
Coke Oven Coke	kt						
Coke Oven Gas	kt						
Coking Coal	kt						
Gas Coke	kt						
Gas Works Gas	GWh	97.62	3.60	351.44	15.20	5341.82	5.34
Lignite	kt						
Other Bituminous Coal	kt						
Patent Fuel	kt						
Peat	kt						
Sub-Bituminous Coal	kt						
Natural Gas							
Natural Gas (Dry)	ktoe	1197.93	41.868	50154.96	15.30	767370.91	767.37
Other Fossil-Based Fuels							
Industrial Waste	kt						
Municipal Solid Waste	kt						
Memo Items							
Gaseous Biomass	kt						
Liquid Biomass	kt						

NOTE

1. Data on international bunker fuels have been reported in a separate memo to the UNFCCC as emissions from such bunker fuels are to be excluded from the national greenhouse gas totals.
2. IPCC default factors are used except for the Emission Factor for Gas Works Gas (15.2) which is a country-specific factor.
3. According to the IPCC Guidelines, autoproducers are classified under the Industry Sector.
4. Natural Gas data which is obtained from EMA in ktoe is multiplied by 0.9 to correct the gross calorific value (GCV) into the net calorific value (NCV), in line with the Revised 1996 IPCC Guidelines.
5. Transformation losses from the production of Gas Works Gas are included under the fuel type "Natural Gas" in the Industry Sector.
6. Emissions from the combustion of Synthesis Gas are included under the fuel type "Refinery Gas" in the Industry Sector.
7. Gas Works Gas was mainly produced from Natural Gas in Singapore.

1A2 - CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)
Country: Singapore
Year: 2010

		STEP 4			STEP 5		STEP 6
		G	H	I	J	K	L
		Fraction of Carbon Stored	Carbon Stored [H=FxG]	Net Carbon Emissions [I=F-H]	Fraction of Carbon Oxidised	Actual Carbon Emissions [K=IxJ]	Actual CO_2 Emissions [L=Kx44/12]
Fuel Types	Unit	1996 IPCC			1996 IPCC		Actual
			(Gg C)	(Gg C)		(Gg C)	(Gg CO_2)
Industry							**16,978.38**
Liquid Fuels							
Crude Oil	kt						
Ethane	kt						
Gas/Diesel Oil	kt	0.00	0.00	444.62	0.99	440.17	1613.96
Gasoline	kt						
Jet Kerosene	kt						
Liquefied Petroleum Gases (LPG)	kt	0.00	0.00	22.78	0.99	22.56	82.71
Lubricants	kt						
Naphtha	kt						
Natural Gas Liquids	kt						
Orimulsion	kt						
Other Kerosene	kt						
Petroleum Coke	kt	0.00	0.00	62.40	0.99	61.78	226.52
Refinery Gas	kt	0.00	0.00	2446.25	0.99	2421.79	8879.88
Residual Fuel Oil	kt	0.00	0.00	915.64	0.99	906.49	3323.79
Solid Fuels							
Anthracite	kt						
Blast Furnace Gas	kt						
Brown Coal Briquettes	kt						
Coke Oven Coke	kt						
Coke Oven Gas	kt						
Coking Coal	kt						
Gas Coke	kt						
Gas Works Gas	GWh	0.00	0.00	5.34	0.995	5.32	19.49
Lignite	kt						
Other Bituminous Coal	kt						
Patent Fuel	kt						
Peat	kt						
Sub-Bituminous Coal	kt						
Natural Gas							
Natural Gas (Dry)	ktoe	0.00	0.00	767.37	0.995	763.53	2799.62
Other Fossil-Based Fuels							
Industrial Waste	kt						
Municipal Solid Waste	kt						
Memo Items							
Gaseous Biomass	kt						
Liquid Biomass	kt						

1A3 - CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)
Country: Singapore
Year: 2010

		STEP 1	STEP 2		STEP 3		
		A	B	C	D	E	F
		Consumption	Conversion Factor	Consumption [C=AxB]	Carbon Emission Factor	Carbon Content [E=CxD]	Carbon Content [F=E/1000]
Fuel Types	Unit	Actual (Quantity)	1996 IPCC (TJ/Unit)	Actual (TJ)	1996 IPCC (t C/TJ)	(t C)	(Gg C)
Transport							
Road Transport							
Gas/Diesel Oil	kt	1157.70	43.33	50162.92	20.20	1013291.07	1013.29
Gasoline	kt	760.53	44.80	34071.79	18.90	643956.81	643.96
Liquefied Petroleum Gases (LPG)	kt						
Natural Gas (Dry)	ktoe	20.68	41.868	865.62	15.30	13244.00	13.24
Rail Transport							
Anthracite	kt						
Coke Oven Coke	kt						
Gas/Diesel Oil	kt						
Other Bituminous Coal	kt						
Residual Fuel Oil	kt						
Pipeline Transport							
Natural Gas (Dry)	ktoe						
National Navigation							
Gas/Diesel Oil	kt	207.28	43.33	8981.31	20.20	181422.51	181.42
Gasoline	kt						
Lubricants	kt						
Residual Fuel Oil	kt						
Sub-Bituminous Coal	kt						
Domestic Aviation							
Gasoline	kt						
Jet Kerosene	kt						
Memo Items							
Liquid Biomass	kt						

NOTE

1. Data on international bunker fuels have been reported in a separate memo to the UNFCCC as emissions from such bunker fuels are to be excluded from the national greenhouse gas totals.
2. IPCC default factors are used except for the Emission Factor for Gas Works Gas (15.2) which is a country-specific factor.
3. According to the IPCC Guidelines, autoproducers are classified under the Industry Sector.
4. Natural Gas data which is obtained from EMA in ktoe is multiplied by 0.9 to correct the gross calorific value (GCV) into the net calorific value (NCV), in line with the Revised 1996 IPCC Guidelines.
5. Transformation losses from the production of Gas Works Gas are included under the fuel type "Natural Gas" in the Industry Sector.
6. Emissions from the combustion of Synthesis Gas are included under the fuel type "Refinery Gas" in the Industry Sector.
7. Gas Works Gas was mainly produced from Natural Gas in Singapore.

1A3 - CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)

Country: Singapore

Year: 2010

		STEP 4			STEP 5		STEP 6
		G	H	I	J	K	L
		Fraction of Carbon Stored	Carbon Stored [H=FxG]	Net Carbon Emissions [I=F-H]	Fraction of Carbon Oxidised	Actual Carbon Emissions [K=IxJ]	Actual CO_2 Emissions [L=Kx44/12]
Fuel Types	Unit	1996 IPCC			1996 IPCC		Actual
			(Gg C)	(Gg C)		(Gg C)	(Gg CO_2)
Transport							**6,722.69**
Road Transport							
Gas/Diesel Oil	kt	0.00	0.00	1013.29	0.99	1003.16	3678.25
Gasoline	kt	0.00	0.00	643.96	0.99	637.52	2337.56
Liquefied Petroleum Gases (LPG)	kt						
Natural Gas (Dry)	ktoe	0.00	0.00	13.24	0.995	13.18	48.32
Rail Transport							
Anthracite	kt						
Coke Oven Coke	kt						
Gas/Diesel Oil	kt						
Other Bituminous Coal	kt						
Residual Fuel Oil	kt						
Pipeline Transport							
Natural Gas (Dry)	ktoe						
National Navigation							
Gas/Diesel Oil	kt	0.00	0.00	181.42	0.99	179.61	658.56
Gasoline	kt						
Lubricants	kt						
Residual Fuel Oil	kt						
Sub-Bituminous Coal	kt						
Domestic Aviation							
Gasoline	kt						
Jet Kerosene	kt						
Memo Items							
Liquid Biomass	kt						

1A4 - CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)
Country: Singapore
Year: 2010

		STEP 1	STEP 2		STEP 3		
		A	B	C	D	E	F
		Consumption	Conversion Factor	Consumption [C=AxB]	Carbon Emission Factor	Carbon Content [E=CxD]	Carbon Content [F=E/1000]
Fuel Types	Unit	Actual (Quantity)	1996 IPCC (TJ/Unit)	Actual (TJ)	1996 IPCC (t C/TJ)	(t C)	(Gg C)
Commercial - Institutional Sector							
Liquid Fuels							
Gas/Diesel Oil	kt						
Gasoline	kt						
Jet Kerosene	kt						
Liquefied Petroleum Gases (LPG)	kt	76.36	47.31	3612.54	17.20	62135.76	62.14
Other Kerosene	kt						
Residual Fuel Oil	kt						
Solid Fuels							
Anthracite	kt						
Brown Coal Briquettes	kt						
Coke Oven Coke	kt						
Coke Oven Gas	kt						
Gas Works Gas	GWh	811.90	3.60	2922.85	15.20	44427.33	44.43
Lignite	kt						
Other Bituminous Coal	kt						
Natural Gas							
Natural Gas (Dry)	ktoe	7.10	41.868	297.26	15.30	4548.12	4.55
Memo Items							
Gaseous Biomass	kt						
Liquid Biomass	kt						

NOTE

1. Data on international bunker fuels have been reported in a separate memo to the UNFCCC as emissions from such bunker fuels are to be excluded from the national greenhouse gas totals.
2. IPCC default factors are used except for the Emission Factor for Gas Works Gas (15.2) which is a country-specific factor.
3. According to the IPCC Guidelines, autoproducers are classified under the Industry Sector.
4. Natural Gas data which is obtained from EMA in ktoe is multiplied by 0.9 to correct the gross calorific value (GCV) into the net calorific value (NCV), in line with the Revised 1996 IPCC Guidelines.
5. Transformation losses from the production of Gas Works Gas are included under the fuel type "Natural Gas" in the Industry Sector.
6. Emissions from the combustion of Synthesis Gas are included under the fuel type "Refinery Gas" in the Industry Sector.
7. Gas Works Gas was mainly produced from Natural Gas in Singapore.

1A4 - CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)
Country: Singapore
Year: 2010

		STEP 4			STEP 5		STEP 6
		G	H	I	J	K	L
		Fraction of Carbon Stored	Carbon Stored [H=FxG]	Net Carbon Emissions [I=F-H]	Fraction of Carbon Oxidised	Actual Carbon Emissions [K=IxJ]	Actual CO_2 Emissions [L=Kx44/12]
Fuel Types	Unit	1996 IPCC			1996 IPCC		Actual
			(Gg C)	(Gg C)		(Gg C)	(Gg CO_2)
Commercial - Institutional Sector							**404.23**
Liquid Fuels							
Gas/Diesel Oil	kt						
Gasoline	kt						
Jet Kerosene	kt						
Liquefied Petroleum Gases (LPG)	kt	0.00	0.00	62.14	0.99	61.51	225.55
Other Kerosene	kt						
Residual Fuel Oil	kt						
Solid Fuels							
Anthracite	kt						
Brown Coal Briquettes	kt						
Coke Oven Coke	kt						
Coke Oven Gas	kt						
Gas Works Gas	GWh	0.00	0.00	44.43	0.995	44.21	162.09
Lignite	kt						
Other Bituminous Coal	kt						
Natural Gas							
Natural Gas (Dry)	ktoe	0.00	0.00	4.55	0.995	4.53	16.59
Memo Items							
Gaseous Biomass	kt						
Liquid Biomass	kt						

1A4 - CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)
Country: Singapore
Year: 2010

		STEP 1	STEP 2		STEP 3		
		A	B	C	D	E	F
		Consumption	Conversion Factor	Consumption [C=AxB]	Carbon Emission Factor	Carbon Content [E=CxD]	Carbon Content [F=E/1000]
Fuel Types	Unit	Actual (Quantity)	1996 IPCC (TJ/Unit)	Actual (TJ)	1996 IPCC (t C/TJ)	(t C)	(Gg C)
Residential Sector							
Liquid Fuels							
Gas/Diesel Oil	kt						
Gasoline	kt						
Liquefied Petroleum Gases (LPG)	kt	19.69	47.31	931.49	17.20	16021.57	16.02
Other Kerosene	kt						
Residual Fuel Oil	kt						
Solid Fuels							
Anthracite	kt						
Brown Coal Briquettes	kt						
Coke Oven Coke	kt						
Coke Oven Gas	kt						
Gas Works Gas	GWh	627.01	3.60	2257.22	15.20	34309.71	34.31
Lignite	kt						
Other Bituminous Coal	kt						
Patent Fuel	kt						
Peat	kt						
Sub-Bituminous Coal	kt						
Natural Gas							
Natural Gas (Dry)	ktoe						
Memo Items							
Gaseous Biomass	kt						
Liquid Biomass	kt						

NOTE

1. Data on international bunker fuels have been reported in a separate memo to the UNFCCC as emissions from such bunker fuels are to be excluded from the national greenhouse gas totals.
2. IPCC default factors are used except for the Emission Factor for Gas Works Gas (15.2) which is a country-specific factor.
3. According to the IPCC Guidelines, autoproducers are classified under the Industry Sector.
4. Natural Gas data which is obtained from EMA in ktoe is multiplied by 0.9 to correct the gross calorific value (GCV) into the net calorific value (NCV), in line with the Revised 1996 IPCC Guidelines.
5. Transformation losses from the production of Gas Works Gas are included under the fuel type "Natural Gas" in the Industry Sector.
6. Emissions from the combustion of Synthesis Gas are included under the fuel type "Refinery Gas" in the Industry Sector.
7. Gas Works Gas was mainly produced from Natural Gas in Singapore.

1A4 - CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)
Country: Singapore
Year: 2010

		STEP 4			STEP 5		STEP 6
		G	H	I	J	K	L
		Fraction of Carbon Stored	Carbon Stored [H=FxG]	Net Carbon Emissions [I=F-H]	Fraction of Carbon Oxidised	Actual Carbon Emissions [K=IxJ]	Actual CO_2 Emissions [L=Kx44/12]
Fuel Types	Unit	1996 IPCC			1996 IPCC		Actual
			(Gg C)	(Gg C)		(Gg C)	(Gg CO_2)
Residential Sector							**183.33**
Liquid Fuels							
Gas/Diesel Oil	kt						
Gasoline	kt						
Liquefied Petroleum Gases (LPG)	kt	0.00	0.00	16.02	0.99	15.86	58.16
Other Kerosene	kt						
Residual Fuel Oil	kt						
Solid Fuels							
Anthracite	kt						
Brown Coal Briquettes	kt						
Coke Oven Coke	kt						
Coke Oven Gas	kt						
Gas Works Gas	GWh	0.00	0.00	34.31	0.995	34.14	125.17
Lignite	kt						
Other Bituminous Coal	kt						
Patent Fuel	kt						
Peat	kt						
Sub-Bituminous Coal	kt						
Natural Gas							
Natural Gas (Dry)	ktoe						
Memo Items							
Gaseous Biomass	kt						
Liquid Biomass	kt						

1A - NON-CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)

Country: Singapore

Year: 2010

Activity			STEP 1						STEP 2						
			Fuel Consumption (TJ)						Emission Factors (kg/TJ)						
			A 1	A 2	A 3	A 4	A 5	A 6	B 1	B 2	B 3	B 4	B 5	B 6
			Coal	Natural Gas	Oil	Wood / Wood Waste	Charcoal	Other Biomass and Wastes	Coal	Natural Gas	Oil	Wood / Wood Waste	Charcoal	Other Biomass and Wastes
Energy and transformation Industries				242,818.49	79,284.40					1	3			
Industry				49,712.44	67,675.32					5	2			
Transport	Domestic Aviation													
	Road	Gasoline		865.62						50				
		Diesel												
	Railways													
	National Navigation				8,981.31						5			
Other Sectors	Commercial - Institutional			297.26						5				
	Residential													
	Agriculture / Forestry / Fishing	Stationary												
		Mobile												
Other (not elsewhere specified)														
Total				**291,481.00**	**155,941.03**									

NOTE

1. The IPCC Tier 2 methodology is used for computing CH_4 and N_2O emissions from petrol and diesel vehicles as the vehicle population statistics are available from the Land Transport Authority.

1A - NON-CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)

Country: Singapore

Year: 2010

			STEP 3						STEP 4	STEP 5	STEP 6
			C								
			Emissions by Fuel (kg)						Total CH_4 Emissions (Gg)	GWP	Total CH_4 Emissions in CO_2eq (Gg)
			C=(AxB)								F = D x E
			C 1	C 2	C 3	C 4	C 5	C 6	D= sum	E	F
Activity			Coal	Natural Gas	Oil	Wood / Wood Waste	Charcoal	Other Biomass and Wastes	(C1..C6) / 1 000 000		
Energy and transformation Industries				242,818.49	237,853.20				0.48	21	10.09
Industry				248,562.21	135,350.64				0.38	21	8.06
Transport	Domestic Aviation										
					Gasoline	Diesel					
	Road			43,281.05					0.04	21	0.91
	Railways										
	National Navigation				44,906.56				0.04	21	0.94
Other Sectors	Commercial - Institutional			1,486.31					0.0015	21	0.03
	Residential										
	Agriculture / Forestry / Fishing	Stationary									
		Mobile									
Other (not elsewhere specified)											
Total				**536,258.03**	**418,110.40**				**0.95**	**21**	**20.04**

1A - NON-CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)

Country: Singapore

Year: 2010

Activity			STEP 1 Fuel Consumption (TJ)						STEP 2 Emission Factors (kg/TJ)					
			A 1	A 2	A 3	A 4	A 5	A 6	B 1	B 2	B 3	B 4	B 5	B 6
			Coal	Natural Gas	Oil	Wood / Wood Waste	Charcoal	Other Biomass and Wastes	Coal	Natural Gas	Oil	Wood / Wood Waste	Charcoal	Other Biomass and Wastes
Energy and transformation Industries				242,818.49	79,284.40					0.1	0.6			
Industry				49,712.44	67,675.32					0.1	0.6			
Transport	Domestic Aviation													
	Road	Gasoline		865.62						0.1				
		Diesel												
	Railways													
	National Navigation				8,981.31						0.6			
Other Sectors	Commercial - Institutional			297.26						0.1				
	Residential													
	Agriculture / Forestry / Fishing	Stationary												
		Mobile												
Other (not elsewhere specified)														
Total				**291,481.00**	**155,941.03**									

NOTE

1. The IPCC Tier 2 methodology is used for computing CH_4 and N_2O emissions from petrol and diesel vehicles as the vehicle population statistics are available from the Land Transport Authority.

1A - NON-CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)

Country: Singapore

Year: 2010

			STEP 3						STEP 4	STEP 5	STEP 6
			C								
			Emissions by Fuel (kg)						Total N_2O Emissions (Gg)	GWP	Total N_2O Emissions in CO_2eq (Gg)
			C=(AxB)								F = D x E
			C 1	C 2	C 3	C 4	C 5	C 6	D= sum	E	F
Activity			Coal	Natural Gas	Oil	Wood / Wood Waste	Charcoal	Other Biomass and Wastes	(C1..C6) / 1 000 000		
Energy and transformation Industries				24,281.85	47,570.64				0.07	310	22.27
Industry				4971.24	40,605.19				0.05	310	14.13
Transport	Domestic Aviation										
					Gasoline / Diesel						
	Road			86.56					0.0001	310	0.03
	Railways										
	National Navigation				5,388.79				0.0054	310	1.67
Other Sectors	Commercial - Institutional			29.73					0.000030	310	0.01
	Residential										
	Agriculture / Forestry / Fishing	Stationary									
		Mobile									
Other (not elsewhere specified)											
Total				**29,148.10**	**93,564.62**				**0.12**	**310**	**38.04**

1A3 - NON-CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 2)
Country: Singapore
Year: 2010

Vehicle Type	Fuel Type	Vehicle Population	Emission Factor (g/ kg fuel)	Weighted -average Emission Factor	IPCC Table
Cars	Petrol	589,034	0.3	0.23566	I-36
Taxis	Petrol	230	0.3	0.00009	I-36
Tax Exempted Cars	Petrol*	2,561	0.3	0.00102	I-36
Motorcycles & Scooters+	Petrol	147,275	5.0	0.98205	I-42
Tax Exempted Motorcycles	Petrol*	878	5.0	0.00585	I-42
Buses+	Petrol	233	0.8	0.00025	I-40
Light Goods Vehicles (LGVs)	Petrol	9,627	0.8	0.01027	I-40
Sub-Total		**749,838**		1.2352	
Cars	Diesel	138	0.08	0.00006	I-37
Taxi	Diesel	23,214	0.08	0.00992	I-37
Buses-	Diesel	15,657	0.2	0.01672	I-39
Tax Exempted Buses-	Diesel*	373	0.2	0.00040	I-39
Light Goods Vehicles (LGVs)	Diesel*	88,924	0.06	0.02849	I-38
Heavy Goods Vehicles (HGVs)	Diesel*	45,044	0.2	0.04810	I-39
Tax Exempted Goods Vehicles-	Diesel*	13,928	0.2	0.01487	I-38
Sub-Total		**187,278**		**0.1186**	
Cars	Hybrid	3,305			
Taxis	Hybrid	30			
Cars	CNG	2,706			
Taxis	CNG	2,599			
Cars	Electric	2			
Motorcycles	Electric	7			
Buses	CNG	44			
Buses	Hybrid	2			
Light Goods Vehicles (LGVs)	CNG	17			
Total		**936,201**			

Type of Fuel (Sales in Singapore)	2010 Fuel Sales (kg)	Weighted-average Emission Factor (g/ kg fuel)	CH_4 Emissions (tonnes)	CH_4 Emissions (kilotonnes-CO_2-equiv)
Petrol	760,531,000	1.2352	939.41	19.73
Diesel	1,157,695,000	0.1186	137.26	2.88

NOTE

1. The IPCC Tier 2 methodology is used for computing CH_4 and N_2O emissions from petrol and diesel vehicles as the vehicle population statistics are available from the Land Transport Authority.
2. The average weighted emission factor is calculated based on the following formula: (vehicle population) / sub-total vehicle population by fuel type) * emission factor.
3. The weighted average emission factor by fuel type (petrol or diesel) is the sum of the individual weighted average emission factors by vehicle type.

1A3 - NON-CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 2)
Country: Singapore
Year: 2010

Vehicle Type	Fuel Type	Vehicle Population	Emission Factor (g/ kg fuel)	Weighted -average Emission Factor	IPCC Table
Cars	Petrol	589,034	0.8	0.62844	I-36
Taxis	Petrol	230	0.8	0.00025	I-36
Tax Exempted Cars	Petrol*	2,561	0.8	0.00273	I-36
Motorcycles & Scooters+	Petrol	147,275	0.06	0.01178	I-42
Tax Exempted Motorcycles	Petrol*	878	0.06	0.00007	I-42
Buses+	Petrol	233	0.06	0.00002	I-40
Light Goods Vehicles (LGVs)	Petrol	9,627	0.06	0.00077	I-40
Sub-Total		**749,838**		**0.6441**	
Cars	Diesel	138	0.2	0.00015	I-37
Taxi	Diesel	23,214	0.2	0.02479	I-37
Buses-	Diesel	15,657	0.1	0.00836	I-39
Tax Exempted Buses-	Diesel*	373	0.1	0.00020	I-39
Light Goods Vehicles (LGVs)	Diesel*	88,924	0.2	0.09496	I-38
Heavy Goods Vehicles (HGVs)	Diesel*	45,044	0.1	0.02405	I-39
Tax Exempted Goods Vehicles-	Diesel*	13,928	0.2	0.01487	I-38
Sub-Total		**187,278**		**0.1674**	
Cars	Hybrid	3,305			
Taxis	Hybrid	30			
Cars	CNG	2,706			
Taxis	CNG	2,599			
Cars	Electric	2			
Motorcycles	Electric	7			
Buses	CNG	44			
Buses	Hybrid	2			
Light Goods Vehicles (LGVs)	CNG	17			
Total		**936,201**			

Type of Fuel (Sales in Singapore)	2010 Fuel Sales (kg)	Weighted-average Emission Factor (g/ kg fuel)	N_2O Emissions (tonnes)	N_2O Emissions (kilotonnes-CO_2-equiv)
Petrol	760,531,000	0.6441	489.83	151.85
Diesel	1,157,695,000	0.1674	193.79	60.07

NOTE

1. The IPCC Tier 2 methodology is used for computing CH_4 and N_2O emissions from petrol and diesel vehicles as the vehicle population statistics are available from the Land Transport Authority.
2. The average weighted emission factor is calculated based on the following formula: (vehicle population) / sub-total vehicle population by fuel type) * emission factor.
3. The weighted average emission factor by fuel type (petrol or diesel) is the sum of the individual weighted average emission factors by vehicle type.

2 - EMISSIONS FROM INDUSTRIAL PROCESSES
Country: Singapore
Year: 2010

Direct Emissions		A	B	C
				C = AxB / 10^6
Greenhouse Gas (GHG)	Chemical Formula	Total (Direct and by-product) emissions for each GHG	Global Warming Potential	Emissions in CO_2 equivalent
		kg		Gg CO2-eq
HFC-23	CHF_3	3,407.26	11,700	39.86
HFC-32	CH_2F_2	108.00	650	0.07
PFC-14	CF_4	74,385.34	6,500	483.50
PFC-116	C_2F_6	49,998.66	9,200	459.99
PFC-218	C_3F_8	5,804.10	7,000	40.63
PFC-c318	c-C_4F_8	435.91	8,700	3.79
Sulphur hexafluoride	SF_6	3,608.89	23,900	86.25

2 - EMISSIONS FROM INDUSTRIAL PROCESSES
Country: Singapore
Year: 2010

Industrial Processes (Semiconductor Manufacturing)			
Emissions in CO_2 equivalent	HFCs	Gg CO_2-eq	39.94
	PFCs	Gg CO_2-eq	987.91
	SF_6	Gg CO_2-eq	86.25

NOTE

1. The IPCC Tier 2 methodology is used for computing of HFCs, PFCs and SF6 emissions.
2. Country-specific factors are used where they are available

6C - EMISSIONS FROM WASTE INCINERATION
Country: Singapore
Year: 2010

CO_2	A	B	C	D	E	F	G
							G=AxBxCxDxExF
	Total Amount of Plastic Waste Incinerated (Dry Weight)	Dry Matter Content	Fraction of Carbon in Dry Matter	Fraction of Fossil Carbon in Total Carbon	Oxidation Factor	Conversion Factor	Fossil CO_2 Emissions
	kt	fraction	fraction	fraction	fraction	44/12	Gg
	430.5	1	0.75	1	1	3.6667	1,183.86

6C - EMISSIONS FROM WASTE INCINERATION
Country: Singapore
Year: 2010

N_2O	Total Amount of Waste Incinerated (Wet Weight)	N_2O Emission Factor	N_2O Emissions	Emissions in CO_2 equivalent
	tonnes	kg N_2O/kt waste	Gg	Gg
	2,585,366.73	47	0.122	37.67

NOTE

1. The CO_2 emissions are added to the total emissions from fuel combustion (All Energy - Fuel combustion - Energy and Transformation Industries).
2. The N_2O emissions are reflected in CO_2-equivalent in the GHG summary table (Waste - Waste incineration).

6B - EMISSIONS FROM WASTEWATER HANDLING
Country: Singapore
Year: 2010

		A	B	C	D	E	F	G
						E = (A x B x C x D) x (44/28) x 10^{-6}		G = E x F
N_2O	Annual per capita protein intake, Protein	Annual per capita protein intake, Protein	Total Population in Singapore	Fraction of Nitrogen in Protein	Emission factor	N_2O Emissions	Global Warming Potential of N_2O	Emissions in CO_2 equivalent
	gram / person /day	kg/person / year		kg N/ kg protein	kg N_2O-N/ kg sewage-N produced	Gg		Gg
	66.33	24.210	5,076,700	0.16	0.01	0.309	310	95.799

NOTE

1. The annual per capita protein intake is the average of the UNFAO data for ASEAN member states (excluding Myanmar and Singapore as there is no data for these countries).
2. The total population in Singapore is based on the latest data available from DOS.
3. The N_2O emissions are reflected in CO_2-equivalent in the GHG summary (Waste - Wastewater Handling).

6B - EMISSIONS FROM WASTEWATER HANDLING
Country: Singapore
Year: 2010

Uncertainty factor	Fraction of methane captured at the SWDS and flared, combusted or used in another manner	Oxidation factor	Fraction of methane in the SWDS gas (volume fraction)	Fraction of degradable organic carbon (DOC) that can decompose	Methane Correction Factor	Total amount of organic waste prevented from disposal in year x (tons)	Degradable Organic Carbon (by weight) - dry sludge	Degradable Organic Carbon (by weight) - dewatered sludge	Decay constant	CH_4 Emissions in CO_2 equivalent
f	f	OX	F	DOCf	MCF	Wx (tons/yr)	DOC (%)	DOC (%)	k	Gg
0.9	0	0.1	0.5	0.5	1	As per records	0.294	0.074	0.4	71.21

NOTE

1. The CH_4 emissions are reflected in CO_2-equivalent in the GHG summary table (Waste - Wastewater Handling).
2. CH_4 emissions from wastewater handling are computed based on CDM methodologies.

6B - EMISSIONS FROM WASTEWATER HANDLING
Country: Singapore
Year: 2010

Incineration of sludge			
Emissions in CO_2 equivalent	CH_4	Gg	0.04668
	N_2O	Gg	17.293

NOTE

1. The CH_4 and N_2O emissions in CO_2-equivalent are added to the total emissions from fuel combustion (All Energy - Fuel combustion - Energy and Transformation Industries).
2. Emissions from the incineraton of sludge are computed based on CDM methodologies.

GREENHOUSE GAS SUMMARY TABLE FOR 2000

Country: Singapore
Year: 2000

As reported in Singapore's Second National Communication.

Greenhouse Gas Source and Sink Categories	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Total (Net) National Emissions (Gg CO_2-eq per year)	**37,755.81**	**111.72**	**334.87**	**7.47**	**496.06**	**84.04**
All Energy	37,755.81		189.26			
Fuel Combustion	37,755.81					
Energy and transformation industries	20,973.74					
Industry	10,526.41					
Transport	5,621.57		189.26			
Commercial-institutional	291.63					
Residential	342.46					
Fugitive fuel emission						
Oil and natural gas systems						
Industrial Processes				7.47	496.06	84.04
Waste		111.72	145.61			
Wastewater handling		111.72	73.75			
Waste incineration			71.86			

NOTE

1. The greenhouse gas emissions from agriculture, land-use change and forestry sectors are negligible in comparison with the size of carbon stocks and in comparison with other economic sectors.

GREENHOUSE GAS SUMMARY TABLE FOR 1994

Country: Singapore
Year: 1994

As reported in Singapore's Initial National Communication.

Greenhouse Gas Source and Sink Categories	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Total (Net) National Emissions (Gg CO_2-eq per year)	**26,800.18**	**0.00**	**0.19**	**0.00**	**0.00**	**0.00**
All Energy	26,800.18					
Fuel Combustion	26,800.18					
Energy and transformation industries	13,141.90					
Industry	8,922.33					
Transport	4,099.99					
Commercial-institutional	327.79					
Residential	308.17					
Fugitive fuel emission						
Oil and natural gas systems						
Industrial Processes						
Waste			0.19			
Wastewater handling			0.19			
Waste incineration						

NOTE

1. The greenhouse gas emissions from agriculture, land-use change and forestry sectors are negligible in comparison with the size of carbon stocks and in comparison with other economic sectors.

Glossary

AAP-JRCC	ASEAN Action Plan on Joint Response to Climate Change
APEC	Asia-Pacific Economic Cooperation
AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
ASEAN RHTN	Association of Southeast Asian Nations Regional Haze Training Network
BAU	Business-As-Usual
BCA	Building and Construction Authority
BESS	Building Energy Submission System
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BREEF	Building Retrofit Energy Efficiency Financing
BSEP	Bus Service Enhancement Programme
C40	C40 Cities Climate Leadership Group
CA	Climate Analytics
CAAS	Civil Aviation Authority of Singapore
CAGR	Compounded Annual Growth Rate
CAS	Coastal Adaptation Study
CBD	Convention on Biological Diversity
CCGT	Combined Cycle Gas Turbine
CCRS	Centre for Climate Research Singapore
CCSU	Carbon Capture, Storage and Utilisation
CDKN	Climate Development Knowledge Network
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CERT	Clean Energy Research Testbedding
CEVS	Carbon Emissions-based Vehicle Scheme
CH_4	Methane
CO_2	Carbon Dioxide
CO_2eq	Carbon Dioxide Equivalent
COP	Code of Practice of Surface Water Drainage
CSB	Centre for Sustainable Buildings
DC	Data Centre
DfE	Design for Efficiency
EASe	Energy Efficiency Improvement Assistance Scheme
ECO-SWM	ECO-Special Waste Management
EDB	Economic Development Board
EE	Energy Efficiency
EEDI	Energy Efficiency Design Index
EHI	Environmental Health Institute
EMA	Energy Market Authority
EXCEL	City Executive Leaders Programme
Exco	Executive Committee
FAO	Food and Agriculture Organisation
FELS	Fuel Economy Labelling Scheme
GCF	Green Climate Fund
Gg	Gigagram
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GM	Green Mark
GMGFA	Green Mark Gross Floor Area
GMIS-EB	Green Mark Incentive Scheme for Existing Building
GREET	Grant for Energy Efficient Technologies
GTP	Green Technology Programme
GWh	Gigawatts-Hour
GWP	Global Warming Potential
HDB	Housing and Development Board
HEA	Home Energy Auditor
HFCs	Hydrofluorocarbons
IAI	Initiative for ASEAN Integration
ICAO	International Civil Aviation Organisation
ICI	International Climate Initiative
ICT	Information and Communications Technology

IDA	Infocomm Development Authority of Singapore
IMCCC	Inter-Ministerial Committee on Climate Change
IMO	International Maritime Organisation
IPCC	Intergovernmental Panel on Climate Change
JSPP21	Japan-Singapore Partnership Programme for the 21st Century
KCA	Key Category Analysis
kt	Kilo-Tonnes
ktoe	Kilo-Tonnes of Oil Equivalent
ktpa	Kilo-Tonne Per Annum
LCC	Life Cycle Cost Calculator
LDCs	Least Developed Countries
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LTA	Land Transport Authority
MELS	Mandatory Energy Labelling Scheme
MEPS	Minimum Energy Performance Standards
MEWR	Ministry of the Environment and Water Resources
MND	Ministry of National Development
MOF	Ministry of Finance
MOH	Ministry of Health
MPA	Maritime and Port Authority of Singapore
MRT	Mass Rapid Transit
MRV	Measurement, Reporting and Verification
MT	Million Tonnes
MWp	Mega-Watt Peak
N_2O	Nitrous Oxide
NAMAs	Nationally Appropriate Mitigation Actions
NCCS	National Climate Change Secretariat
NEA	National Environment Agency
NGOs	Non-Governmental Organisations
NParks	National Parks Board
NRF	National Research Foundation
OPC	Off-Peak Car
PFCs	Perfluorocarbons
PUE	Power Usage Effectiveness
PV	Photovoltaic
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
REDD	Reducing Emissions from Deforestation and Forest Degradation
RMS	Risk Map Study
RWG	Resilience Working Group
SCP	Singapore Cooperation Programme
SCS	Solar Capability Scheme
SDCC	Sustainable Development and Climate Change
SEEMP	Ship Energy Efficiency Management Plan
SF_6	Sulphur Hexafluoride
SIDS	Small Island Developing States
SIWW	Singapore International Water Week
SLA	Singapore Land Authority
SSTEC	Sino-Singapore Tianjin Eco-city
UFW	Unaccounted-for-Water
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP-SBCI	United Nations Environment Programme Sustainable Building and Climate Initiative
UNFCCC	United Nations Framework Convention on Climate Change
URA	Urban Redevelopment Authority
WCS	World Cities Summit
WRI	World Resources Institute
WTO	World Trade Organisation

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