SINGAPORE'S

Fourth National Communication and Third 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

The impact of climate change has become increasingly palpable around the world. The need for climate action has become more urgent than ever. The Inter-Governmental Panel on Climate Change (IPCC)'s *Special Report on Global Warming of 1.5°C (SR1.5)* released in October 2018 reinforces the need for the international community to stem the warming trend as soon as possible to forestall the worst effects of climate change.

The Paris Agreement has set clear long-term temperature goals. We need to keep the global temperature rise this century to well below 2°C above pre-industrial levels, and strive to limit temperature increase to 1.5°C. This requires ambitious collective climate action. As a responsible member of the international community, Singapore will play our part.

Singapore is a small, low-lying, island city-state exposed to the effects of climate change. In particular, we are vulnerable to rising sea levels and extreme weather events. Through consistent implementation of environmentally friendly measures over many years, such as market pricing of energy, tree-planting, stringent restraints on car ownership and use, and encouraging energy efficiency, our emissions intensity is among the lowest in the world. Although we only account for around 0.11% of global emissions, we are committed to contributing to the global effort to address climate change.

The Climate Action Plan which we launched in 2016 comprehensively outlines our mitigation and adaptation plans. As our geography limits the potential for alternative energy sources, our key strategy remains to improve energy efficiency in all sectors of our economy. From 2000 to 2014, Singapore's economy grew at a compounded annual growth rate (CAGR) of 5.5% while our emissions grew at a slower CAGR of 2.0%. We are well on track to achieve our 2009 Copenhagen pledge to reduce emissions by 16% below our business-as-usual (BAU) level in 2020. We will build on these efforts as we work under the Paris Agreement to further reduce our emissions intensity by 36% from 2005 levels by 2030, and to stabilise our emissions with the aim of peaking around 2030.

Singapore will be the first country in Southeast Asia to implement a carbon tax from 2019. It will be applied uniformly across all sectors without exemptions so that all emitters have to take into account the negative externalities of carbon emissions. The carbon tax will send an economy-wide price signal to incentivise emission reductions and adoption of low-carbon technologies. The carbon tax will complement our comprehensive suite of mitigation measures and help us achieve our climate pledges.

As a small, low-lying island nation, we have also developed long-term plans to strengthen our adaptive capacity. These include significant infrastructure investments such as raising the platform height of coastal areas and roads, introducing new building codes, and enhancing our drainage and flood management systems. We introduced new technology like desalination and NEWater to expand and diversify our water supply. We are also taking steps to strengthen our resilience in public health and food supply.

Singapore has designated 2018 as the Year of Climate Action to encourage greater national consciousness to the urgent need for climate action. Since its launch, we have received more than 300,000 pledges from individuals, businesses, organisations, and educational institutions. In the public sector, all our ministries have pledged to reduce their plastic, water, and electricity consumption. We will continue to work with all stakeholders to galvanise bottom-up efforts to complement our mitigation measures.

Climate change calls for concerted international action. The IPCC SR1.5 highlighted that the long-term temperature goals of the Paris Agreement can be met if we take urgent climate action today. Singapore stands ready to play our part and to work with the international community to do so. We will continue to push for sustainable development and develop a low-carbon, climate-resilient Singapore for our current and future generations.

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 (UNFCCC), Singapore is obliged to submit our National Communications (NC) every four years[1] and our 1st Biennial Update Report (BUR) to the UNFCCC in 2014.[2]

Singapore submitted our 3rd NC in 2014. As the submission year for Singapore's 4th NC coincides with the submission year of our 3rd BUR, this document presents both Singapore's 4th NC and 3rd 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
- 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 (decision 2/CP.17 annex III).

[1] UNFCCC decision 1/CP.16
[2] UNFCCC decision 2/CP.17

FOURTH NATIONAL COMMUNICATION
UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Executive Summary

Singapore is a small, low-lying, island city-state vulnerable to the effects of climate change.

Given Singapore's small size and dense urban landscape, there are challenges to using alternative energy sources such as solar, nuclear, and wind energy. Such difficulties in switching to alternatives are recognised by the United Nations Framework Convention on Climate Change (UNFCCC).

Singapore's greenhouse gas emissions for 2014 totalled 50,908.13 gigagram CO_2-equivalent. Carbon dioxide (CO_2) accounted for 95.5% 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 4.5% of total emissions.

Singapore is currently working to reduce emissions by 16% below 2020 business-as-usual (BAU) levels in line with its 2009 Copenhagen pledge. Having ratified the Paris Agreement on 21 September 2016, Singapore has also formalised its Nationally Determined Contribution (NDC), which aims to reduce the country's Emissions Intensity by 36% from 2005 levels by 2030, and to stabilise its emissions with the aim of peaking around 2030.

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 taken steps to use a cleaner fuel mix for electricity generation, switching from fuel oil to natural gas. However, there are limits to how much more emissions can be reduced by switching fuels, as natural gas currently constitutes about 95% of our fuel mix for electricity generation. While Singapore continues to invest actively in research on clean energy technologies to reduce the use of fossil fuels, there are limits to its deployment of alternative or renewable energy sources.

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. From 2019, Singapore will implement a carbon tax of S$5 per tonne of CO_2-equivalent (tCO_2e) of greenhouse gas emission (GHG) in the first instance, between 2019 and 2023, as a transition period. We intend to increase it to S$10-15/$tCO_2e$ by 2030. The carbon tax will complement our existing mitigation efforts to meet our climate pledge under the Paris Agreement.

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) continues to play an important role in coordinating 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.

CHAPTER 1
NATIONAL CIRCUMSTANCES

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

> “ Singapore’s geographical features limit access to alternative energy sources.

CHAPTER 1

NATIONAL CIRCUMSTANCES

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

Although we contribute around 0.11% 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 719.9 km^2. Much of the island is flat and relatively low-lying. As of 2017, Singapore's total population, including foreigners working in Singapore, is estimated to be 5.6 million. Singapore's population density of about 7,796 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.

Such difficulties in switching to alternative energy sources are recognised by the United Nations Framework Convention on Climate Change (UNFCCC).[3]

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

Solar PV technology has been identified as a key renewable energy source that has high potential for large-scale deployment in Singapore.

[3] 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."

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 and Coordinating Minister for National Security, the IMCCC includes the Minister for the Environment and Water Resources, the Minister for Finance, the Minister for Foreign Affairs, the Minister for National Development, the Minister for Trade and Industry and the Minister for Transport.

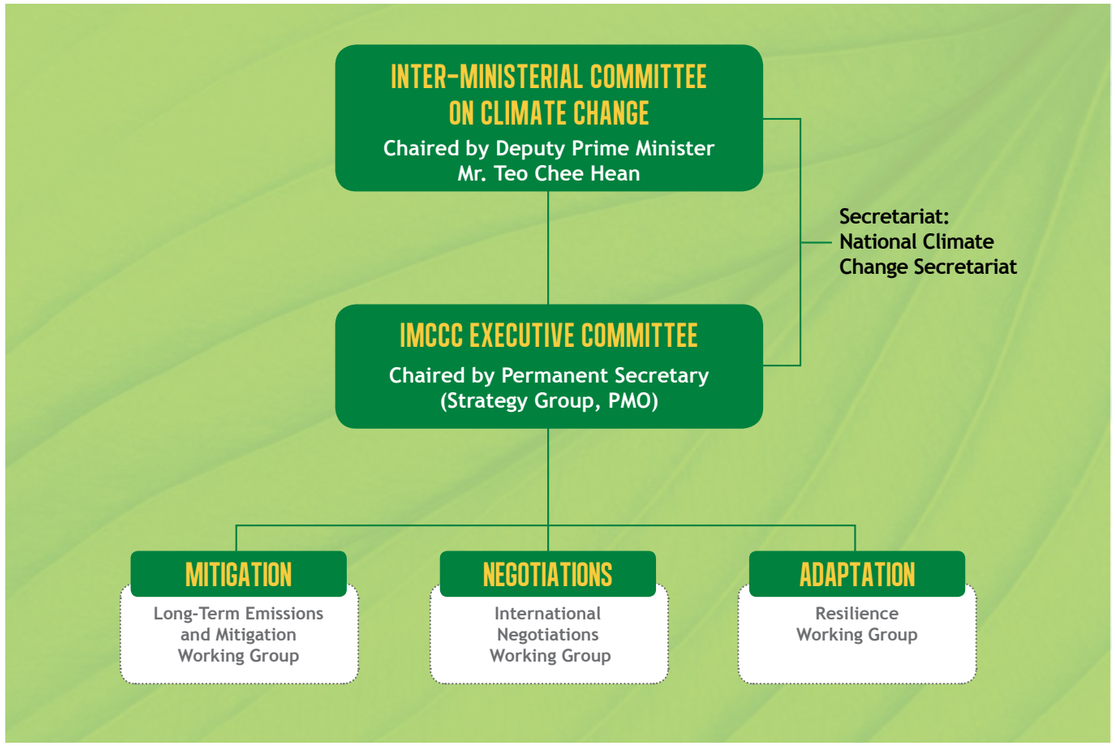
The IMCCC is supported by an Executive Committee (Exco) which oversees the work of three working groups:

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 to build Singapore's resilience.

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.



Climate Action Plan

In July 2016, the Singapore Government released the Climate Action Plan which includes two complementary publications outlining Singapore's plans to address climate change. Titled 'Take Action Today, For a Carbon-Efficient Singapore' and 'A Climate-Resilient Singapore, For a Sustainable Future', the two publications detail Singapore's strategies to reduce greenhouse gas emissions to meet our 2030 pledge under the Paris Agreement and to adapt to the impacts of climate change.

Public Education

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. National programmes such as energy labelling and vehicular emissions schemes empower consumers to make informed purchasing decisions based on the energy efficiency of household appliances and motor vehicles.

Campaign visual for Energy-Saving Challenge

To raise the level of national consciousness on the need for collective climate action, Singapore has designated 2018 as the Year of Climate Action. As part of the campaign, over 300,000 individuals and organisations (as of October 2018) have committed to taking action to address climate change. To support ground-up initiatives, a Climate Action SG Grant was set up to co-fund projects by NGOs and interest groups that promote climate action messages, the 3Rs (Reduce, Reuse, Recycle) and energy conservation. The National Environment Agency (NEA) also organised an Energy-Saving Challenge to encourage households to adopt energy saving habits and reduce their energy consumption.

The new Sustainable Singapore Gallery at the Marina Barrage features an interactive exhibit on Singapore's updated climate action plan. The exhibit highlights the potential impacts of climate change on Singapore and includes a game to help visitors understand how they can reduce their carbon footprint.

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).

The new Sustainable Singapore Gallery at the Marina Barrage features an interactive exhibit on Singapore's updated Climate Action Plan

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.








> “Although we contribute around 0.11% of global emissions, we will continue to take steps to reduce our carbon emissions.

CHAPTER 2

NATIONAL GREENHOUSE GAS INVENTORY REPORT

The most significant greenhouse gas (GHG) 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 (33.4%) is the combustion of natural gas to generate electricity.

Singapore's emissions for carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) were estimated using the:

- Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories
- IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories
- IPCC 2014, 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands

Emission estimates were based on the sectoral approach and were made using the default conversion and emission factors provided in the 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, CO_2 emissions from waste incineration and HFCs, PFCs and SF_6 from integrated circuit and semiconductor production under Industrial Processes and Product Use. Emission estimates from the Land Use, Land-Use Change and Forestry (LULUCF) sector were obtained mainly from using Tier 2 or 3 methodologies.

Singapore's Greenhouse Gas Emissions in 2014

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	48,620.43	95.51%
PFCs	1,146.83	2.25%
N_2O	452.90	0.89%
HFCs	306.41	0.60%
CH_4	199.60	0.39%
SF_6	181.96	0.36%

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 GHG emissions were developed based on the 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 3 of the Biennial Update Report (BUR).

CHAPTER 3

MITIGATION MEASURES

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.

> "Singapore is well on track to meet our 2020 pledge of reducing emissions by 16% below business-as-usual levels.

CHAPTER 3

MITIGATION MEASURES

Singapore is well on track to meet our 2020 pledge of reducing emissions by 16% below 2020 business-as-usual[4] (BAU) levels. Building on our 2020 pledge, Singapore has also formalised our 2030 commitment as outlined in our Nationally Determined Contribution (NDC). Singapore aims to reduce our Emissions Intensity by 36% from 2005 levels by 2030, and stabilise our emissions with the aim of peaking around 2030.

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 95% of our fuel mix for electricity generation in 2016. 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.

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 the adoption of energy efficient measures and technologies by addressing market barriers to energy efficiency.
- Building capabilities 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 capabilities 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 at least 80% of the total gross floor area in Singapore to achieve Green Buildings standard by 2030. For the transport sector, we already have a high public transport mode share. To further encourage the use of public transport, the length of the rail network in Singapore will increase from 230km today to about 360km by 2030. This will enable 8 in 10 households to be within a ten-minute walk of a train station, and 85% of public transport journeys of less than 20km to be completed within 60 minutes. We also have one of the most stringent and innovative systems in the world for controlling vehicle ownership and usage, through a vehicular quota and road pricing system. Since February 2018, the permissible growth rate of private vehicle population has been reduced to zero per cent, from 0.25%, effectively capping the growth of private vehicles. In 2013, we introduced a system of rebates and surcharges to encourage car buyers to purchase low-emissions cars.

From 2019, Singapore will implement a carbon tax starting at S$5 per tonne of CO_2-equivalent (tCO_2e) of greenhouse gas (GHG) emissions in the first instance, between 2019 and 2023, as a transition period. We intend to increase it to S$10-15/$tCO_2e$ by 2030. The carbon tax will send an economy-wide price signal to incentivise emission reductions and adoption of low-carbon technologies. The carbon tax will complement our comprehensive suite of mitigation measures and help us achieve our climate pledges.

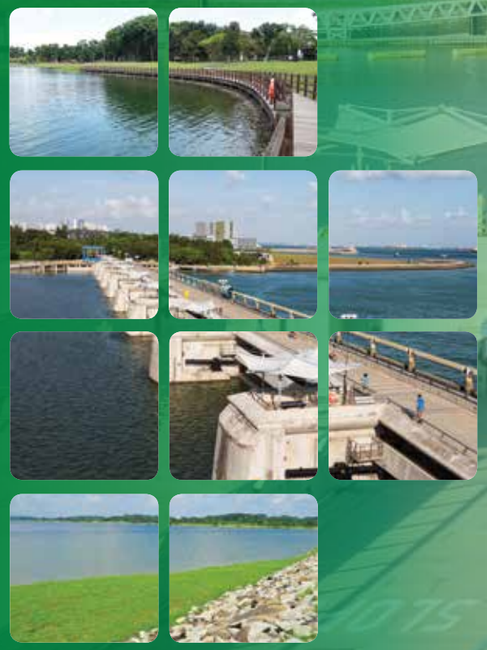
More information on Singapore's mitigation measures are presented in Chapter 4 of the Biennial Update Report (BUR).

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

CHAPTER 4

VULNERABILITY AND ADAPTATION MEASURES

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.



> "It is important for Singapore to prepare for and adapt early to climate change.

CHAPTER 4

VULNERABILITY AND ADAPTATION MEASURES

As a small, low-lying island city state of 719.9 km^2, Singapore is naturally vulnerable to the impact of climate change. With a population of 5.6 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 end century 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[5] 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, Singapore conducted the Second National Climate Change Study in 2015, which made use of data and scenarios from the AR5 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 about 1m and temperatures could increase by up to 4.6°C by 2100. The findings from the study are generally consistent with the projections from AR5.

[5] 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.

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 on global climate projections, it is necessary for Singapore to translate these global findings into Singapore's context through high-resolution modelling and a deep understanding of regional climate dynamics.

Therefore, in March 2013, the Meteorological Service Singapore (MSS) established the Centre for Climate Research Singapore (CCRS) to develop local research expertise in the weather and climate of Singapore and the wider Southeast Asia region. In 2015, CCRS completed the Second National Climate Change Study, which analysed the future climate for Singapore and the Southeast Asian region at high spatial resolution. The findings from this study provide the scientific basis for Singapore's adaptation plans.

CCRS is currently developing high-resolution modeling systems for weather and climate prediction, and will continue to develop climate change projections for Singapore. CCRS's work on climate science will help policy makers make informed decisions to address the potential impact of climate change in Singapore, and thus augment our national preparedness for climate change.

External View of the Centre for Climate Research Singapore

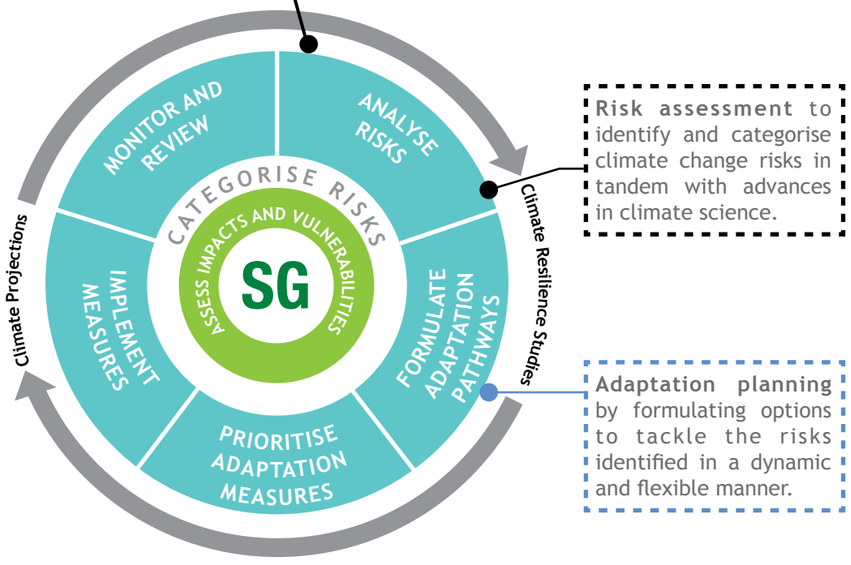
Preparing Singapore for Possible Climate Change Impact

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 ensure that Singapore is prepared for the impact of climate change. Some adaptation measures require lead time to implement, and have to be undertaken 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 impact up to the year 2100 (see below for Singapore's Resilience Framework).

SINGAPORE'S RESILIENCE FRAMEWORK

The Centre for Climate Research Singapore (CCRS) is responsible for undertaking research and studies to improve scientific understanding of local climate and the effects of climate change on Singapore. The studies have provided climate projections which formed the basis for Singapore's long-term adaptation plans. CCRS will be continuing its climate research studies, in collaboration with its partners, to fine tune climate projections which would be used to examine climate change impacts on Singapore.



The agencies in this Working Group include the Ministry of Health (MOH), the Ministry of Finance (MOF), the Agri-Food and Veterinary Authority (AVA), 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 Info-communications Media Development Authority (IMDA), JTC Corporation, the Land Transport Authority (LTA), the Maritime and Port Authority of Singapore (MPA), the National Climate Change Secretariat (NCCS), the National Environment Agency (NEA), the National Parks Board (NParks), 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 across the government 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 Second National Climate Change Study served as input to help shape and refine our resilience plans. They also supported our planners in their scoping of further studies to address information gaps. The preliminary plans and measures that have been implemented are highlighted below.

a) Protecting our Coast

As an island-state, Singapore is vulnerable to the impact of sea level rise. We have taken steps to mitigate the impact of sea level rise. For example, the minimum reclamation levels for newly reclaimed land have been raised from 3m to 4m above the mean sea level in 2011 to cater for sea level rise. BCA is conducting a Coastal Adaptation Study to develop longer term coastal protection strategies for Singapore.

Composite stepped seawall at East Coast Park

b) Managing our Water, Minimising Floods

Water resource management is a key priority. Climate change could lead to greater contrast between the wet and dry seasons, which may threaten our water supply. To ensure a sustainable water supply for Singapore's population and industry, PUB, Singapore's National Water Agency, has built a robust and diversified water supply for Singapore through the "Four National Taps", namely, local catchment water, imported water, NEWater[6] and desalinated water. In particular, NEWater and desalinated water are less dependent on rainfall and are thus more resilient against dry weather.

Singapore is also projected to experience more frequent and intense heavy rainfall events. To enhance flood protection, PUB adopts a "Source-Pathway-Receptor' approach, which looks at catchment-wide solutions to achieve higher drainage and flood protection. This holistic approach covers the entire drainage system, addressing not just the pathway over which the stormwater travels (i.e. "Pathway"), but also controlling rainwater at where it falls onto the ground (i.e. "Source") and the areas where floods may occur (i.e. "Receptor").

All new developments and re-developments of 0.2 hectares or more are required 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 detention tanks or rain gardens and bioretention swales (i.e. "Source" solution). They are also required to adhere to the minimum platform and crest levels or place flood barriers to prevent floodwaters from entering buildings (i.e. "Receptor" solution).

In addition, PUB has raised the drainage design standards since 2011, so that our drains can handle up to 45% higher rainfall intensities (i.e. "Pathway" solution").

c) Safeguarding our Biodiversity and Greenery

Singapore is home to a large variety of animal and plant species, many of which are vulnerable to climate change. For example, coral bleaching occurred in 1998 and 2010 due to high sea surface temperatures. To protect Singapore's marine biodiversity, NParks established Singapore's first marine park at the Sisters' Islands in 2014. The marine park is an ecosystem inhabited by rare and endangered marine animals. Other measures to protect Singapore's biodiversity include restoring mangrove areas in Singapore.

As a City in a Garden, Singapore has around 2 million trees along roadsides, in parks and State lands managed by NParks. NParks inspects trees along major roads and areas with high human activity at least once a year to ensure that they are in good health and resilient to climate change. If needed, trees are pruned to reduce the size and weight of their crowns to better withstand strong winds. Storm-vulnerable trees have also been replaced with hardier species.

Sisters' Islands Marine Park

[6] 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.

Singapore's first release of male Wolbachia-Aedes mosquitoes at Braddell Heights.

d) Strengthening Resilience in Public Health and Food Security

Vector-borne diseases such as dengue are endemic to the Southeast Asian region. Higher temperatures could create prime conditions for mosquitoes to breed and viruses to multiply faster. To minimise dengue incidences, 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. Aedes aegypti mosquitoes are dengue vectors and NEA's Environmental Health Institute (EHI) is exploring the use of Wolbachia technology to reduce the Aedes aegypti mosquito population.

EHI staff transferring male Wolbachia-Aedes pupae into release containers, preparing for male Wolbachia-Aedes mosquito release

90 per cent of Singapore's food supply is imported. To minimise the risk of food supply disruptions, AVA pursues a diversification strategy to import food from countries in a variety of regions. This minimises the potential disruption to Singapore's food supply if a particular region is affected by extreme weather events. Domestically, AVA is working with local farmers to ensure that they are prepared for climate change by increasing productivity and research and development.

e) Keeping our Essential Services Running Well

To ensure that our essential services (energy, telecommunications and transport infrastructure) will not be affected by climate change, agencies have taken early action. LTA has installed flood barriers at entrances and openings of low-lying underground Mass Rapid Transit (MRT) stations and CAAS is upgrading the drainage system at Changi Airport with new detention tanks and pumps.

Future developments are also built to higher standards to account for climate impact such as sea level rise. The future Changi Airport Terminal 5 will be built 5.5m above mean sea level and the new Tuas mega port will be built more than 2m higher than the highest water level observed.

EMA and IMDA will factor in climate impact when strengthening the resilience of Singapore's energy supply and telecommunication services.

f) Keeping our Buildings and Infrastructure Safe

The buildings in Singapore may be affected by climate change. Analyses so far have indicated that the structural integrity of buildings in Singapore will not be affected by the projected changes in temperature, rainfall, and wind speeds as long as the buildings adhere to building codes and are properly maintained. BCA and HDB are conducting additional studies to understand the impact on building attachments.

With climate change, more frequent and heavier rainfall could affect the stability of our slope. BCA is also studying adaptation strategies that can address the increased risk of slope failure due to climate change.

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 future Assessment Reports by IPCC, it is necessary to leverage on global and regional-level findings and translate them at the national level to update our knowledge and resilience plans. This will be carried out in future National Climate Change Studies.

Climate change resilience goes beyond physical adaptation. Resilience must involve the entire community. 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. Making early adjustments will make this transition easier.

CHAPTER 5

INTERNATIONAL COOPERATION

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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) and the Paris Agreement on climate change provide 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 and the Paris Agreement. Singapore ratified the UNFCCC in 1997 and acceded to the Kyoto Protocol in 2006. We ratified the Paris Agreement in September 2016, and was one of the first 55 Parties to do so, thereby contributing to the early entry into force of the Paris Agreement on 4 November 2016. Although we contribute around 0.11% of global emissions, we 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. Under the Paris Agreement, we made a further commitment to reduce our emissions intensity by 36% from 2005 levels by 2030, and to stabilise our greenhouse gas emissions with the aim of peaking around 2030.

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 multilateral organisations.

As a member of the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), and a member on their Councils, Singapore participates in, and contributes to, their efforts to address international aviation and maritime transport emissions on a global basis. At the ICAO, Singapore is actively involved in the development of its holistic strategy and basket of measures to mitigate international aviation emissions, including the use of technologies, operational improvements, market-based measures, and development and deployment of sustainable aviation fuels. Singapore actively supports the IMO's work on the Initial Strategy on the Reduction of Greenhouse Gas (GHG) Emissions from Ships, and its work and regulations to improve the energy efficiency, and thereby reduce the emissions of ships.

In addition to implementing the standards and requirements of the ICAO and the IMO on international transport emissions, the Singapore aviation and maritime transport sectors voluntarily take various initiatives and measures to mitigate these emissions. In the international aviation sector, Singapore submitted early and regularly updates our State Action Plan to the ICAO. As outlined in our State Action Plan, Singapore's air navigation service operator invests in state-of-the-art technologies and enters into partnerships to implement air traffic management (ATM) measures to enhance the efficiency of over 660,000 aircraft movements in the Singapore Flight Information Region that helps to reduce their fuel burn and emissions. Singapore carriers are also modernising their fleets with more fuel-efficient aircraft and engines, conducting more efficient flight operations and flight trials using sustainable aviation fuels, and adopting best practices in aircraft and engine maintenance.

In the maritime transport sector, Singapore launched the Maritime Singapore Green Initiative (MSGI) to reduce the environmental impact of shipping and shipping-related activities on the coastal and marine environment, with an initial funding pledge by the Maritime and Port Authority of Singapore (MPA) of up to S$100 million over five years. The MSGI has since been extended and further enhanced. Among the various initiatives, stakeholders are encouraged to adopt environmentally friendly practices and reduce the environmental impact of operations through voluntary programmes. The MSGI also supports local maritime technology companies in developing and deploying green technologies through co-funding grants. MPA is also working closely with other international port authorities and maritime administrations to build a network of LNG bunker-ready ports to facilitate the greater adoption of LNG for global shipping.[7] In addition, MPA has set aside S$6 million to support the building of LNG bunker vessels to enable ship-to-ship LNG bunkering operations.

We have also engaged and collaborated with other UN agencies and programmes on specific initiatives to address climate change. For example, the Building and Construction Authority (BCA) of Singapore has been working closely with UN Environment to promote standards for sustainable buildings in the region. The BCA Centre for Sustainable Buildings was established by the 2nd BCA-UNEP Memorandum of Understanding (MOU) in 2011, to provide technical support, tools, and solutions for the building sector in Asia. In 2013, the BCA and UN Environment established a five-year partnership project, the "Nationally Appropriate Mitigation Action (NAMA) Development for the Building Sector in Asia", which supports four participating Asian countries – Indonesia, the Philippines, Thailand, and Viet Nam – in developing national plans to reduce greenhouse gas emissions in their building sectors. The project is part of the International Climate Initiative supported by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

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 of 2018, close to 300 applications for GM certification have been received from 14 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.

We also play a leading role to support global actions to put the building sector on a 1.5-2°C pathway. The Global ABC is an initiative launched at the 21st Conference of the Parties to the UNFCCC, as part of the Lima Paris Action Agenda (LPAA). It aims to scale up actions within the buildings and construction sector to reduce emissions. Singapore hosted the Global ABC's inaugural Regional Roundtable for Asia Pacific in conjunction with the International Green Building Conference in September 2016. The two-day event involved a series of activities to meet the global sustainable buildings and climate change agenda. This included a presentation of UN Environment's Finance Initiative publication, "Sustainable Real Estate Investment – Implementing the Paris Climate Agreement: An Action Framework", and the Working Session of the Sustainable Energy for All (SE4All) Building Efficiency Accelerator. It was attended by more than 85 participants from national governments, local authorities, NGOs, international financial institutions and academic/research institutions from fourteen countries in the region.

[7] The network includes Japan Ministry of Land, Infrastructure, Transport and Tourism (MLIT); Belgium Antwerp Port Authority and Port of Zeebrugge; the Netherlands Port of Rotterdam Authority; Norwegian Maritime Authority; the ROK Ulsan Port Authority; Port of Ningbo-Zhousan; Port of Marseille Fos; Port of Vancouver; and the JAX Chamber.

Regional Cooperation

Singapore is committed to working with the Association of Southeast Asian Nations (ASEAN) to address climate change. At the 32nd ASEAN Summit, the ASEAN Leaders acknowledged the need to strengthen ASEAN's capability and capacity to respond to the adverse effects of climate change by facilitating the sharing of information and best practices to enhance the implementation of the Paris Agreement and Nationally Determined Contributions (NDCs), in order to build climate resilient communities in the region. They also agreed to enhance cooperation on climate change, including with ASEAN's Dialogue Partners and external parties. Under our Chairmanship of ASEAN in 2018, Singapore hosted the Special ASEAN Ministerial Meeting on Climate Action (SAMCA) to highlight ASEAN countries' commitment to collectively address climate change through fulfilling our commitments under the Paris Agreement. The SAMCA was held on 10 July 2018, back-to-back with an Expanded SAMCA involving the Presidents of the 23rd and 24th Conference of the Parties to the UNFCCC, Fiji and Poland respectively, as well external partners under the ASEAN Plus Three (i.e. Japan, Republic of Korea and China).

Singapore also participates in the ASEAN Working Group on Climate Change (AWGCC), which was established in 2009 to enhance regional cooperation and action to address the adverse impacts of climate change on socio economic development in ASEAN Member States (AMS). Singapore assumed the Chairmanship of AWGCC for the period 2017-2019. Work under AWGCC is guided by the ASEAN Socio-Cultural Blueprint 2025 and the AWGCC Action Plan 2016-2025 (AAP).

9th Meeting of the ASEAN Working Group On Climate Change (AWGCC) held in Manila, Philippines in June 2018

At the regional level, AMS commit to work towards a climate-resilient ASEAN through the implementation of the AAP, which aims to deliver capacity building programmes and technical exchanges in areas such as adaptation and resilience, mitigation, technology transfer, climate finance, cross-sectoral coordination and global partnership. At present, AMS are working on around 11 projects and activities that have been endorsed by the AWGCC. Some of the expected outcomes from these projects and activities include: (i) strengthening AMS capacity for the implementation of NDCs; and (ii) building AMS capacity on carbon-pricing and laying the foundation for possible cooperation on carbon pricing at the regional level.

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.

Dr Amy Khor, Senior Minister of State, Ministry of the Environment and Water Resources, sat on the panel for the discussion on 'Protecting the Environment and Public Health' at the Clean Environment Leaders Summit.

Innovators presented solutions such as smart cleaning robots and novel uses of incineration bottom ash during the CESS Innovation Pitch at the NEA Innovation Pavilion.

Environment leaders from government agencies, academia and the industry shared their expertise and participated in panel discussions at the Clean Environment Leaders Summit, deep-diving into themes such as green growth models and future technologies.

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, Clean Enviro Summit Singapore as well as the Singapore International Water Week. These events are part of our efforts to bring policy makers and stakeholders in city planning, environment and water management together to examine urban challenges, and identify shared solutions and best practices in areas such as 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 96 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 in sustainable development through webinars, hosting study trips for city councils and actively participating at mayor-level forums. Likewise, C40 enables Singapore to learn from the best practices of other major cities. In 2016, Singapore hosted a high-level C40 event, "From Ambition to Action: The Vital Role of Cities in Achieving the Paris Agreement", which brought together C40 mayors and city experts from around the world. This event provided a platform for various stakeholders to describe the climate actions they were taking as well as the key challenges they faced in doing so, thereby facilitating the exchange of lessons learnt and best practices.

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 levels. Singapore's National Research Foundation (NRF) has also set up CREATE in 2007 as an international campus to forge partnerships between Singapore's universities and research institutions, and leading overseas research institutions. Today, the campus co-locates researchers from the Massachusetts Institute of Technology (MIT), University of California Berkeley (UCB), Cambridge University, ETH Zurich, Technical University of Munich (TUM), Hebrew University of Jerusalem (HUJ), Shanghai Jiao Tong University (SJTU), University of Illinois at Urbana Champaign (UIUC), National University of Singapore (NUS) and Nanyang Technological University (NTU) to conduct interdisciplinary research in areas such as urban design and mobility, environmental sensing and modelling, and low carbon research.

Bilateral Cooperation

At the bilateral level, Singapore has provided technical assistance and capacity-building programmes to officials from fellow developing countries since 1992 on various climate-related issues. These programmes are held under the auspices of the Singapore Cooperation Programme (SCP), our flagship technical assistance programme. To date, over 12,000 participants from more than 170 countries have attended SCP training courses on Sustainable Development and Climate Change-related topics such as sustainable urban development, water management and energy efficiency and emissions reduction.

Renewing our commitment to support efforts in addressing climate change and its impact, Singapore launched a dedicated Climate Action Package (CAP) at the SAMCA in July 2018. This new package is tailored for fellow developing countries, in particular the Small Island Developing States (SIDS) and the Least Developed Countries (LDCs). As part of our attempt to deliver more impactful and relevant programmes, courses under the CAP will be reviewed and refreshed annually to address changing demands. Where possible, Singapore will work with developed country partners and international organisations under the CAP so as to pool expertise and resources. For example, Singapore has partnered Australia to host capacity-building workshops in Singapore on climate finance, and on transparency under the UNFCCC, as part of our joint efforts to help build capacities in developing countries, particularly SIDS.

Regional Capacity-Building Workshop on Transparency under the UNFCCC

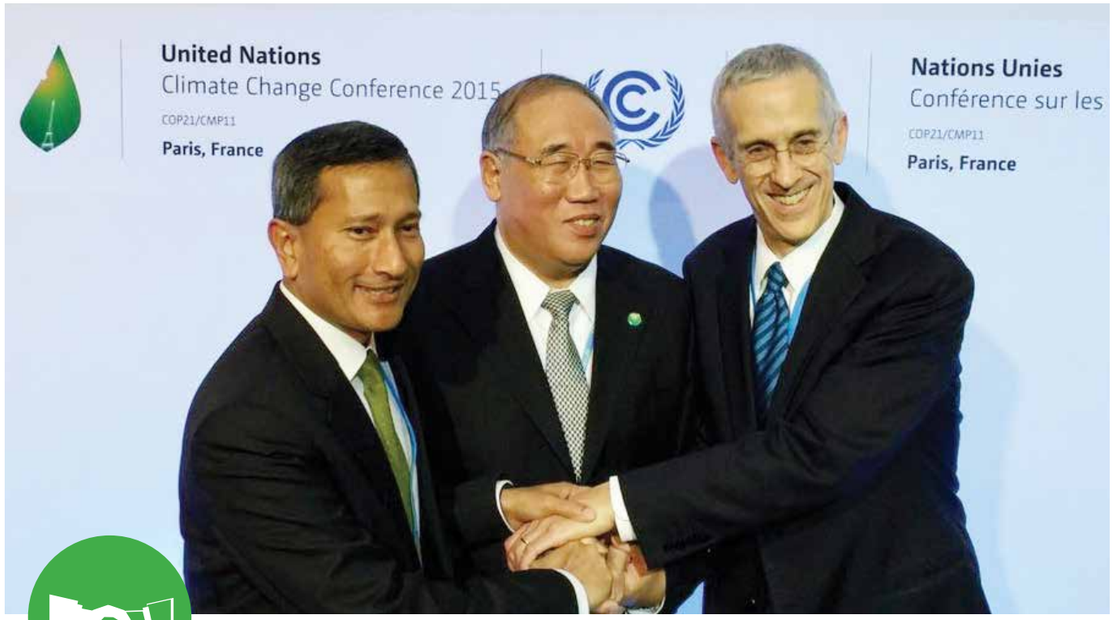
Under the SCP, we have worked with Australia and the UN Development Programme and UN Environment's Global Support Programme for National Communications and Biennial Update Reports to host the regional capacity-building workshop on Transparency under the UNFCCC. The workshop aims to build and sustain the capacity of regional countries in preparing their Biennial Update Reports and in undergoing the International Consultation and Analysis process. It also focuses on strengthening institutional arrangements and the management and retention of information, and technical skills required to effectively sustain the measurement, reporting and verification process over the long-term. The workshop features technical experts from the co-organisers, and trainers and resource persons from other countries and various multilateral organisations, including the UNFCCC Secretariat.

Regional Capacity-Building Workshop on Transparency Under the UNFCCC in Singapore on 4-5 June 2018

Highlights of Sustainable Development and Climate Change (SDCC) Programme

No.	Course Name	Partnerships	Course dates/ duration	Course Description
1	Disaster Risk Reduction and Management	Japan-Singapore Partnership Programme for the 21st Century (JSPP21), World Resources Institute (WRI) and Climate Analytics (CA)	2-week training course in August 2017	The course involved in-depth analysis and discussion on issues and challenges faced by emergency authorities in disaster management at various levels, as well as national development policies and planning on disaster risk reduction.
2	Measurement, Reporting and Verification (MRV) framework under the UNFCCC	Australia and UNEP/UNDP	2-day programme in June 2017 and June 2018	The workshop built and sustained the capacity of Parties in Southeast Asia, Northeast Asia and South Asia that are preparing their Biennial Update Reports and will be undergoing the International Consultation and Analysis process. It also focused on strengthening institutional arrangements and on the management and retention of the information and personnel skills needed to effectively sustain the MRV process over the long-term.
3	International Leaders in Urban Governance	UN-Habitat	Week-long course in June 2017	The programme brought experienced practitioners from both the UN and Singapore to discuss typical urban issues such as Sustainable Environment, Transport and Mobility, Parks/Waterways Development, among others.
4	Sustainable WASH Resources	UNICEF	Week-long programme in October 2017	The course gathered management-level government officials working on WASH and public health matters and built their capacity in these areas through sharing skills and knowledge on water management, urban sanitation and drinking water quality monitoring. It also covered the SDGs, UNCIEF Global Water, Sanitation and Hygiene strategy and tools.
5	Climate Change Adaptation Strategies	SCP Training Awards/Small Island Developing States Technical Cooperation	Week-long programme in July 2017	This programme shared best practices and principles in managing air and water quality and explored sustainable urban development strategies to reduce the impact on the environment.
6	Urban Air and Water Quality Management	SCP Training Awards / Small Island Developing States Technical Cooperation Programme	Week-long programme in July 2017	This programme shared best practices and principles in managing air and water quality and explored sustainable urban development strategies to reduce the impact on the environment.
7	Sustainable Oceans and Marine Resources	SCP Training Awards/Small Island Developing States Technical Cooperation Programme	Week-long programme in July 2017	This programme explored the impact of man's activities on the marine environment and shared a sustainable approach to managing marine resources and marine biodiversity.

Key International Events on Climate Change



Minister Vivian Balakrishnan with Xie Zhenhua, China's Special Representative on Climate Change Affairs and Todd Stern, United States Special Envoy for Climate Change on the night of the Paris Agreement conclusion. Source: Vivian Balakrishnan/Facebook

Singapore signs the Paris Agreement on Climate Change at the United Nations in New York on 22 April 2016. Source: Ministry of Foreign Affairs

Singapore delegation at the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP-21). Source: Ministry of Foreign Affairs.

The Expanded Special ASEAN Ministerial Meeting on Climate Action in Singapore, 10 July 2018

THIRD BIENNIAL UPDATE REPORT
UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

CHAPTER 1

NATIONAL CIRCUMSTANCES

Bishan-Ang Mo Kio Park, which is integrated with a naturalised, meandering river, is one of the largest urban parks in central Singapore, covering a full 62 hectares of greenery.









> The most significant greenhouse gas 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.

CHAPTER 1
NATIONAL CIRCUMSTANCES

Singapore's public housing is home to over 80% of Singapore's resident population.

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 203km. The total land area (including that of smaller islands) is about 719.9km^2. Among the islands, the larger ones are Pulau Tekong (25.5km^2), Pulau Ubin (10.2km^2) and Sentosa (4.8km^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 situated near the equator and has a tropical climate, with relatively uniform temperature, abundant rainfall, and high humidity. The climate of Singapore is characterised by two monsoon seasons separated by inter-monsoonal periods. The Northeast Monsoon occurs from December to early March, and the Southwest Monsoon from June to September. The early part of the Northeast Monsoon, in December and January, is the wetter period of the year when monsoon surges occur, which sometimes bring prolonged heavy rain to Singapore. The later part of the Northeast Monsoon from February to early March is usually much drier, with the driest month of February occurring during this period. The Southwest Monsoon is comparatively drier. Afternoon thunderstorms are common throughout the year, especially during the inter-monsoonal periods from late March to May and October to November. During the Southwest Monsoon and inter-monsoonal periods, widespread heavy rain and gusty winds associated with Sumatra squalls also occur occasionally.

Singapore's 1981-2010 long-term average daily temperature is about 27.5°C, with an average daily maximum of about 31.5°C and an average daily minimum of about 24.7°C. The long-term average annual rainfall is around 2,166mm.

Population

As of 2017, Singapore's total population, including foreigners working in Singapore, is estimated at 5.6 million. The resident population, comprising Singapore citizens and permanent residents, is estimated at 3.9 million or 70% of the total population. Singapore's small land area also means that our population density of about 7,796 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 2017, in nominal terms, Singapore's external merchandise trade amounted to S$967 billion, about 2.2 times the GDP of Singapore (S$447 billion). Over several decades, Singapore has built up a strong economy where manufacturing and wholesale & retail trade sectors each comprised around 19% and 18% of GDP respectively in 2017. 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 around 18% of our total merchandise exports in 2017. Singapore's strategic geographical location has also enabled it to develop into a major air and sea transportation hub. The economic structure in 2017 is as shown.

Economic Structure, 2017
(Nominal Value Added Share, %)

Manufacturing	19.2
Construction	4.3
Utilities	1.3
Other Goods Industries	0.0
Wholesale & Retail Trade	17.6
Transportation & Storage	7.2
Accommodation & Food Services	2.1
Information & Communications	4.2
Finance & Insurance	13.3
Business Services	14.8
Other Services Industries	12
Ownership Of Dwellings	3.9

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. Water demand is expected to double by 2060.

Integral to the large-scale collection of used water for recycling into NEWater is the Deep Tunnel Sewerage System (DTSS). A superhighway for used water management, the DTSS provides a cost-effective and sustainable solution to meet Singapore's long-term needs for used water collection, treatment, reclamation and disposal.

NEWater and desalinated water are not dependent on rainfall, and thus greatly enhance our resilience against dry weather. However, the production of these two sources is more energy-intensive as compared to treating water from the local catchment. To improve the 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.

Managing demand is equally essential to ensuring a sustainable water supply. Singapore adopts a multi-pronged approach in managing its water demand: pricing water to reflect its scarcity value; mandating water efficiency standards and through public education on water conservation practices. Through wide-ranging water conservation measures, Singapore's per capita domestic water consumption reduced from 165 litres per day in 2003 to 143 litres per day in 2017. 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.

Deep Tunnel Sewerage System (DTSS)

Tuas Desalination Plant

Singapore's National Circumstances and Constraints

Singapore currently accounts for around 0.11% 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 potential for alternative energy sources.

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 are a large source of our carbon emissions and Singapore has been working to improve energy efficiency in these sectors. 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.

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.

As Singapore is a small, alternative-energy disadvantaged island city-state with a 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.

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 subclauses 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 currently not viable as a significant energy resource for Singapore, due to our lack of domestic biomass sources and available land to produce biomass. Singapore already converts much of our waste to energy, providing about 2.3% of our energy needs in 2017. Nonetheless, we will continue to study and monitor developments in this area.

Carbon Capture, Storage and Utilisation (CCSU)

Singapore is studying various technologies to identify if there are technologies that could be adopted soon, while concurrently carrying out research to develop technologies that could be adopted in the longer term.

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

Singapore conducted a nuclear energy pre-feasibility study as a preliminary step to assess the feasibility of nuclear energy as an option to meet Singapore's long-term energy needs. The study concluded in 2012 that nuclear energy technologies presently available are not yet suitable for deployment in Singapore. Although newer nuclear power plant designs have the potential to be safer than those in operation today, these newer technologies have not been operationally proven. Nonetheless, Singapore will continue to monitor developments and will focus on research and developing capabilities to keep abreast of progress in nuclear energy so as to keep our options open for the future.

Solar

While Singapore's compact and dense urban landscape limits available space for deployment, solar energy remains the most viable source of renewable/alternative energy in Singapore. Singapore has taken proactive steps to facilitate solar deployment, by enhancing the regulatory framework for intermittent generation sources, and streamlining compliance requirements. The government has also embarked on the SolarNova Programme, which aggregates demand for solar deployment across public sector buildings and spaces, to catalyse the growth of solar energy in Singapore. The lead demand generated has also helped and will continue to support the solar industry to develop its capabilities. In addition, we are actively investing in R&D and test-bedding to improve the efficiencies and lower the costs of solar PV and related technologies.

We are also exploring various solutions to manage the intermittency challenge of solar PV, which if left unaddressed would limit solar deployment. For example, we are studying how energy storage solutions and solar forecasting 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 Most Sustainable City

According to the 2018 Sustainability Cities Index, Singapore is Asia's most sustainable city and 4th globally.[8] The Sustainability Cities Index recognises that Singapore is undertaking several sustainability initiatives which will create a high-quality living environment, that is resilient and in line with the broader climate change agenda. Singapore has also been ranked third in the Global Competitiveness Index in the World Economic Forum (WEF)'s Global Competitiveness Report 2017–2018 underscoring that the sustainability efforts have helped Singapore maintain its competitiveness.

Despite Singapore's immutable geographical realities, our twin goals of growing our economy and protecting the environment remain central to our national strategy. As we pursue further economic development, we remain committed to stabilising our long term emissions. This requires serious efforts across all sectors. Given these challenges, we will need to make inroads into energy efficiency, harness new and disruptive technologies, and shape business decisions and consumer behaviour towards a low carbon future.

In 2017, we introduced several enhancements to the Energy Conservation Act to strengthen the measurement and reporting requirements for greenhouse gas emissions, requiring companies to undertake regular energy efficiency opportunity assessments, and introducing minimum energy performance standards for common industrial equipment and systems. A carbon tax will also be implemented from 2019 to send an economy-wide price signal to incentivise emissions reductions and adoption of low-carbon technologies.

[8] The Sustainable Cities Index is produced by global design and consulting firm Arcadis. It ranks 100 global cities based on three dimensions – people, planet and profit.

Innovation will be key for Singapore to continue to develop sustainably. We are investing in R&D in the urban solutions and sustainability sector, which includes piloting, test-bedding, and accelerating the adoption of new technologies. Although the scale of solar energy deployment in Singapore is limited by space constraints and issues with intermittency, we are exploring innovative ways to overcome our constraints. For instance, we are test-bedding floating solar systems on one of our reservoirs and conducting engineering and environmental studies into the deployment of such systems in other reservoirs.

Despite our constraints and unique circumstances, Singapore is putting in a major effort to stabilise our long-term emissions, as will be described in Chapter 4 on Mitigation Measures.

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 and Coordinating Minister for National Security. It includes the Minister for the Environment and Water Resources, the Minister for Finance, the Minister for Foreign Affairs, the Minister for National Development, the Minister for Trade and Industry and the Minister for Transport. 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 (LWG) 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. A Measurement, Reporting, and Verification (MRV) Task Force under the LWG is tasked with coordinating inter-agency MRV efforts. This includes the preparation of Singapore's National Communications (NC) and Biennial Update Reports (BUR) by an inter-agency working group for approval by the IMCCC and preparing Singapore to undergo the International Consultations and Analysis (ICA) process. 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. NCCS is part of the Strategy Group which supports the Prime Minister and his Cabinet to establish priorities and strengthen strategic alignment across Government. The positioning of NCCS underscores the importance that Singapore places on climate change.

CHAPTER 2

ENHANCING CAPACITIES

Singapore Botanic Gardens was inscribed as a UNESCO World Heritage Site in 2015.

> “Singapore recognises the importance of improving our Measurement, Reporting, and Verification (MRV) processes and identifying opportunities to enhance our climate actions.

CHAPTER 2

ENHANCING CAPACITIES

Primary forest trees, in one of the nature reserves in Singapore, continue to store and sequester carbon.

Singapore recognises the importance of improving our Measurement, Reporting, and Verification (MRV) processes and identifying opportunities to enhance our climate actions. This is an ongoing national effort. We pursue continual learning to fine-tune our technical expertise on a wide range of issues from reporting processes to enhancing our climate change activities. We also actively collaborate with international partners to identify and promulgate best practices in these areas. Although Singapore does not receive any financial support, we have learned much from sharing knowledge and experience through different channels, including through collaborating with experts and participating in technical workshops.

In line with IPCC Good Practice Guidance to continually review the GHG inventory, NEA has updated Singapore's GHG inventory in a consistent manner and to the extent that data is available in the following IPCC Sectors.

1) Industrial Processes and Product Use (IPPU)
   Since the recent introduction of the Energy Conservation Act (ECA) in 2013, which requires registered companies to report their energy use and GHG emissions to NEA on an annual basis, IPPU GHG emissions data has become available. This new data stream has been updated in the national GHG inventory time series.
2) Waste
   In addition to reporting CO_2 emissions from incineration of plastics fraction of solid waste and N_2O emissions from solid waste incineration, Singapore has included CH_4 emissions from solid waste incineration and CO_2 emissions data from the incineration of other non-plastic fossil-based waste[9] (e.g. textiles, rubber) as well as hazardous and clinical waste.[10]
3) Memo items
   Emissions from international bunkers and CO_2 emissions from incineration of non-fossil based fraction of solid waste have been included as a memo item in our GHG inventory. In line with the IPCC guidelines, memo items are reported but excluded from the national totals.

Land Use, Land-Use Change and Forestry Sector

For the Land Use, Land-Use Change and Forestry (LULUCF) sector, we continue to base our computations using a wall-to-wall assessment of the land use and land-use changes in Singapore derived mainly from very high resolution satellite images covering all land-use categories and five carbon pools in accordance to the guidelines provided by the IPCC. The estimates are supported with data collected from field measurement and modelling approaches.

As we continue to enhance our capacity and capture current data to support our computations, we have made a series of improvements that led to changes in the emission trends in the LULUCF sector. A revision on our tree biomass growth rate and corrections of our historical maps which were previously based on interpolations resulted in a shift for some years in the overall LULUCF time series from sink towards source. We describe this further in the LULUCF section of the GHG chapter.

Emissions from the Refrigeration and Air-Conditioning (RAC) Sector

Singapore has developed an interim Tier 1b estimate of HFCs emissions from the refrigeration and air conditioning (RAC) sector. The estimate is 4.24 Mt.[11]

Singapore is in the process of implementing licensing controls on the HFCs regulated under the Kigali Amendment of the Montreal Protocol. The licensing regime will enable Singapore to collect more accurate import and export trade data on HFCs starting from 2020. Building on this, Singapore will develop a Tier 2 estimate of HFCs emissions from the RAC sector which will be included in future BURs.

Reference Approach and Sectoral Approach Emissions

As a global trading hub with a high trade to GDP ratio, Singapore experiences volatility in trade data as a direct result of our large and volatile trade volumes coupled with the presence of a large refining and petrochemical sector. This gives rise to large discrepancies between emissions calculated using the reference approach and sectoral approach. As such, emissions calculated using the sectoral approach would be more accurate than using the reference approach in Singapore's context.

Nevertheless, Singapore will be undertaking a study in 2019 to better understand the reasons for the discrepancies.

[9] More details on Solid Waste Management can be found in the Chapter 3 of the BUR: National GHG Inventory.
[10] More details on hazardous and clinical waste can be found in the Chapter 3 of the BUR: National GHG Inventory.
[11] The estimate includes a minute quantity (0.0003 Mt) of PFC-116 emissions.

CHAPTER 3

NATIONAL GREENHOUSE GAS INVENTORY

At 36 metres above ground, the Henderson Waves bridge is the highest pedestrian bridge in Singapore.

> “Given Singapore’s small land size and highly urbanized landscape, the greenhouse gas emissions from Agriculture and Land Use, Land-Use Change and Forestry sectors are negligible in comparison with the size of carbon stocks and in comparison with other economic sectors.

CHAPTER 3
NATIONAL GREENHOUSE GAS INVENTORY

Since early 2000s, Singapore has taken steps to use a cleaner fuel mix for electricity generation, switching from fuel oil to natural gas.

The most significant 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. Given Singapore's small land size and highly urbanized landscape, the greenhouse gas emissions from Agriculture and Land Use, 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

Revised 1996 IPCC Guidelines

Singapore's emissions were mainly estimated using the Revised 1996 IPCC Guidelines for National GHG 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.

2006 IPCC Guidelines

The emissions from waste incineration and industrial processes and product use were estimated using the 2006 IPCC Guidelines for National GHG Inventories. The emission estimates for CH_4 and N_2O from hazardous waste incineration and CO_2, CH_4 and N_2O from clinical waste incineration were also made using the 2006 IPCC Guidelines. The Tier 2 methodology, with default conversion and emission factors from the 2006 IPCC Guidelines, was used for estimating emissions of CO_2 from waste incineration and HFCs, PFCs and SF_6 from integrated circuit and semiconductor production under Industrial Processes and Product Use. Emissions from the LULUCF sector were obtained mainly from using Tier 2 or 3 methodologies based on the IPCC (2006) Guidelines and IPCC (2014) Wetlands Supplement, where applicable.

IPCC Good Practice Guidance

The emissions of CO_2 from hazardous waste incineration were estimated using the IPCC Good Practice Guidance.

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.

Global Warming Potentials

The estimated CH_4, N_2O, HFCs, PFCs and SF_6 emissions were converted to CO_2-equivalent (CO_2-eq) 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

Precursors

Emissions of precursors such as carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs) and other gases such as sulphur dioxide (SO_2) are not included in the inventory. The levels of these gases in the air are currently monitored by a network of ambient air quality monitoring stations. CO, NO_x and SO_2 are considered air pollutants and are regulated under the Environmental Protection and Management Act (EPMA) which stipulates emission standards for these pollutants. Strict enforcement programmes and air quality monitoring have helped to ensure that the emissions of all these precursors are minimised and that air quality remains good.

Singapore's Emissions for 2014

Singapore's GHG emissions for 2014 totalled 50,908.13 gigagram (Gg) CO_2-eq. A breakdown of the total GHG emissions by sources for 2014 in Gg CO_2-eq is shown in the table below.

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)	48,620.43	199.60	452.90	306.41	1,146.83	181.96
All Energy	**48,035.60**	**94.56**	**302.76**			
Fuel combustion	**47,092.02**	**40.60**	**301.90**			
Energy and transformation industries	19,518.10	6.73	71.95			
Industry	20,277.21	10.94	13.44			
Transport	6,662.98	22.86	216.48			
Commercial-institutional	426.61	0.08	0.02			
Residential	207.12	NE	NE			
Fugitive fuel emission	**943.58**	**53.96**	**0.87**			
Oil and natural gas system[12]	943.58	53.96	0.87			
Industrial Processes and Product Use (IPPU)	**334.67**	**77.16**	**44.95**	**306.41**	**1,146.83**	**181.96**
Agriculture	**NE**	**NE**	**NE**			
Land Use, Land-Use Change and Forestry	**53.64**	**NO**	**8.39**			
Waste	**196.53**	**27.88**	**96.80**			
Wastewater Handling		27.88	94.92			
Hazardous Waste Incineration	194.62	~0.00	1.83			
Clinical Waste Incineration	1.91	~0.00	0.05			
Memo item[13]						
Biomass	1,674.47					

*NO means Not Occurring; NE means Not Estimated.

[12] Fugitive fuel emissions from oil and natural gas systems are based on company-level data.
[13] Emissions from memo items are not included in the national GHG emissions.

The breakdown of emissions by type of gas is as shown.

Greenhouse Gas	Emissions (Gg CO_2e)	Percentage of Total Emissions
CO_2	48,620.43	95.51%
PFCs	1,146.83	2.25%
N_2O	452.90	0.89%
HFCs	306.41	0.60%
CH_4	199.60	0.39%
SF_6	181.96	0.36%

Worksheets

The 2014 GHG inventory worksheets are appended in the Annex.

Previously reported Greenhouse Gas Emissions

A breakdown of the total GHG emissions by sources reported in previous National Communications and Biennial Update Report (1994, 2000, 2010 and 2012) in Gg CO_2-eq can also be found in the Annex.[14]

Emissions from International Bunkers in 2014

International bunkers	CO_2 emissions (Gg CO_2-eq)[15]
Aviation	13,375.47
Marine	130,570.48

Note: As Singapore is a major international air and sea transportation hub, aviation and marine bunker fuels are uplifted in Singapore as part of the services provided to passing aircraft and ships on international routes. Emissions from international aviation and marine bunker fuels are therefore excluded from Singapore's national greenhouse gas inventory and national greenhouse gas totals.

[14] In line with the IPCC Good Practice Guidance to continually review the GHG inventory ensuring that it is compiled in a consistent manner, emission estimates may have been updated.
[15] Emissions factors from the IPCC Guidelines were applied for the purpose of submission of data on greenhouse gas from international bunkers to the UNFCCC only.

Breakdown of Emissions by IPCC Sector

All Energy

The combustion of fossil fuels to generate energy is the major source of GHG emissions in Singapore. The amount of emissions emitted from the energy sector (fuel combustion) in 2014 was 48,432.92 Gg CO_2eq. The contribution of emissions from fuel combustion in the energy sector and fugitive fuel emissions in 2014 is as shown.

Sector	Emissions (Gg CO_2e)	% of Total Emissions
Industry (Energy Use)	20,301.60	41.92%
Energy and Transformation Industries[16]	19,596.79	40.46%
Transport	6,902.32	14.25%
Industry (Fugitive Emissions)	998.40	2.06%
Commercial-Institutional	426.70	0.88%
Residential	207.12	0.43%

As heat from the incineration of waste is recovered to produce electricity in Singapore, CO_2, CH_4 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-based and the non-fossil-based fraction is excluded.[17]

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

[16] Emissions from waste incineration and sludge incineration are included here.

[17] More details regarding waste incineration and sludge incineration can be found in the section under Waste.

Electricity Generation

In 2014, electricity generation emissions totalled 19,596.79 Gg CO_2eq. The breakdown of emissions from different fuel types used for electricity generation in 2014 is as shown.

Fuel Type	Emissions (Gg CO_2e)	% of Total Emissions from Energy & Transformation Industries
Natural Gas	16,980.25	86.65%
Waste	1,628.95	8.30%
Coal	901.08	4.60%
Diesel	75.66	0.39%
Fuel Oil	10.84	0.06%

Electricity consumed in the same year was 46,403.0 gigawatt-hours (GWh). Consumption of electricity by various sectors is as shown.[18]

End-Use Sector	Electricity Consumed (GWh)	% of Total Electricity Consumption
Industry-related	19,753.20	42.57%
Commerce & Service-Related	17,046.60	36.74%
Household	6,924.40	14.92%
Transport-related	2,441.00	5.26%
Others	237.70	0.51%

**Note: Figures including additions may not tally due to rounding difference.*

[18] Source: Energy Market Authority, Singapore Energy Statistics 2018, Table 3.2

Industry (Energy Use)

The majority of the direct emissions from the industrial sector are 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 breakdown of emissions by fuel type in the industrial sector is as shown.

Fuel Type	Emissions (Gg CO_2e)	% of Total Emissions from Industry
Refinery Gas	11,088.09	54.62%
Natural Gas	4,537.31	22.35%
Fuel Oil	2,562.42	12.62%
Diesel	1,572.66	7.75%
Petroleum Coke[19]	541.11	2.66%

Industry (Fugitive Emissions)

The Energy Conservation Act (ECA) was introduced in 2013 and mandates energy-intensive companies in the industrial sector to monitor and report their energy use and GHG emissions on an annual basis. Companies under the ECA will compute their fugitive[20] and IPPU emissions[21] based on the 2006 IPCC Guidelines and submit their reports as part of their regulatory requirements.

The sources of fugitive emissions compiled from the ECA include, but are not limited to, equipment leaks, evaporation and flashing losses, venting, flaring, incineration and accidental releases. The main contribution to fugitive emissions are the flaring of waste gases from process upsets and/or maintenance activities.

The amount of fugitive fuel emissions is small, accounting for only 1.96% of the national GHG inventory.

Transport

In 2014, Singapore had a network of 3,495km of paved public roads and a population of 972,037 motor vehicles.[22] These motor vehicles consumed diesel, petrol and compressed natural gas (CNG).

Marine Gas Oil/Marine Diesel Oil (MGO/MDO) was consumed by harbour and pleasure crafts plying within the waters of Singapore.

[19] Emissions from the combustion of Liquefied Petroleum Gases (LPG) and Gas Works Gas are included here.

[20] Prior to 2013, fugitive fuel emissions from oil and natural gas systems were based on company-level surveys.

[21] More details regarding IPPU emissions can be found in the section under IPPU.

[22] Source: Land Transport Authority, Singapore Land Transport: Statistics in Brief 2015.

The breakdown of emissions by fuel type in the transport sector is as shown.

Sector	Fuel Type	Emissions (Gg CO_2e)	% of Total Emissions from Transport
Transport (Land)	Diesel	4,245.81	61.51%
	Petrol	2,419.84	35.06%
	CNG	40.28	0.58%
Transport (Marine)	MGO/MDO used in harbour and pleasure craft	196.39	2.85%

Commercial-Institutional and Residential

Emissions from the commercial and residential sectors were from the use of Liquefied Petroleum Gas (LPG) and Gas Works Gas,[23] mainly for cooking and hot water systems. The breakdown of emissions by fuel type in the commercial and residential sectors is as shown.

Fuel Type	Emissions (Gg CO_2e)	% of Total Emissions from Commercial-Institutional Sector
LPG	211.34	49.53%
Gas Works Gas	174.92	40.99%
Natural Gas	40.44	9.48%

Fuel Type	Emissions (Gg CO_2e)	% of Total Emissions from Residential Sector
Gas Works Gas	136.67	65.99%
LPG	70.45	34.01%

[23] 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.

Industrial Processes and Product Use (IPPU)

The Energy Conservation Act (ECA) was introduced in 2013 and mandates energy-intensive companies in the industrial sector to monitor and report their energy use and GHG emissions on an annual basis. Companies under the ECA will compute their IPPU emissions based on the 2006 IPCC Guidelines and submit their reports as part of their regulatory requirements. This new data stream is included from 2013.

The majority of the emissions from the IPPU sector are from the electronics sector. In the electronics sector, although HFCs, PFCs and SF_6 were used in the manufacturing process, emission control technologies were installed in some processes. This is followed by emissions from the chemical industry, where CO_2 and CH_4 emissions were emitted from ethylene and ethylene oxide production.

The breakdown of emissions by type of gas in the IPPU sector is as shown.

Type of Gas	Emissions (Gg CO_2e)	% of Total Emissions from IPPU
PFCs	1,146.83	54.82%
CO_2	334.67	16.00%
HFCs	306.41	14.64%
SF_6	181.96	8.70%
CH_4	77.16	3.69%
N_2O	44.95	2.15%

Waste

Solid Waste Management

Singapore has adopted waste-to-energy incineration technology to reduce the volume of waste disposed of at landfill since 1970s. As heat from the incineration of waste is recovered to produce electricity, according to the 2006 IPCC Guidelines, CO_2, CH_4 and N_2O emissions from waste incineration are reported in the energy sector. Biogenic CO_2 emissions from the incineration of non-fossil-based waste are excluded from the national total emission estimates, and are included as a memo item in the energy sector.

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

CH_4 and N_2O emissions were estimated based on the amount of waste incinerated at the waste-to-energy incineration plants.

Sludge Incineration

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 have been significantly reduced by incinerating the sludge.[24] As heat from the incineration of sludge is recovered to produce electricity, according to the Revised 1996 IPCC Guidelines, CH_4 and N_2O emissions from incineration of sludge are reported in the energy sector.

Wastewater Handling

Used water is conveyed, via sewers, to water reclamation plants for treatment. This includes, among other processes, an activated sludge process. The sludge is further stabilised in digesters. The biogas produced in the digesters is used as fuel to generate electricity to power the operation of the treatment facilities. 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).[25]

The breakdown of emissions by type of gas from the wastewater handling is as shown.

Type of Gas	Emissions (Gg CO2e)	% of Total Emissions from Wastewater Handling
N_2O	94.92	77.30%
CH_4	27.88	22.70%

Hazardous and Clinical Waste Incineration

Facilities engaged in hazardous and clinical waste incineration in Singapore are regulated by NEA under the Environmental Public Health Act (EPHA). The activity data submitted by these facilities to NEA was used to estimate the emissions of CO_2, CH_4 and N_2O.

The breakdown of emissions by type of gas from hazardous waste incineration is as shown.

Type of Gas	Emissions (Gg CO_2e)	% of Total Emissions from Hazardous Waste Incineration
CO_2	194.62	99.07%
N_2O	1.83	0.93%
CH_4	~0.00	~0.00%

The breakdown of emissions by type of gas from clinical waste incineration is as shown.

Type of Gas	Emissions (Gg CO_2e)	% of Total Emissions from Clinical Waste Incineration
CO_2	1.91	97.36%
N_2O	0.05	2.64%
CH_4	~0.00	~0.00%

[24] 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. From 2012 onwards, emissions from the incineration of sewage sludge were estimated by PUB based on the forward trend extrapolation of available data from 2010 and 2011.

[25] Singapore's 2014 annual per capita protein intake is estimated from Southeast Asia's average per capita protein intake (Source: UN Food and Agriculture Organisation (FAO)) as Singapore-specific figures are not available.

Agriculture

The GHG 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.

Farming of leafy vegetables in Singapore

Land Use, Land-Use Change and Forestry

A system to capture removals and emissions from the Land Use, Land-Use Change and Forestry sector (LULUCF) has been designed to ensure compliance following the approach under the 2006 IPCC Guidelines on LULUCF.

Estimation and reporting of the GHG removals and emissions were carried out for all land use and land-use change categories in Singapore and assessed for all five carbon pools. The main land-use categories (Forest Land, Cropland, Wetlands and Settlements) were further subdivided into subcategories for assessment of their respective contributions to the removals and emissions. The category Grassland is not relevant for Singapore, as lawns and grassland patches are located in between infrastructure, in urban parks and stocked forests, and subsumed under the Forest Land category or under Settlements using specific emission factors for such low vegetation. The category Other Land is not occurring in Singapore. However a unique category "Other" is included to capture emissions from land losses to the sea due to construction measures, while removals from land reclamation measures are included in the respective land-use subcategories.

For all land-use change categories, the IPCC approach of estimating removals and emissions in all pools for a transition period of 20 years was applied. Methods employed in the assessment follow higher tier approaches, where required. The land use and land-use change matrix was assessed based on a wall-to-wall mapping using very high resolution satellite images. Emission factors of any significant pools of subcategories were estimated with Tier 2 or 3 approaches and on basis of country specific data, resulting out of field measurement of tree biomass and soil inventory and estimated by modelling approaches.

The C stock change rates of biomass and soil in land-use change areas to the Forest Land subcategory "Mangroves" were taken from the IPCC (2014) Wetlands Supplement and complemented by country-specific C stocks from published literature. Biomass C stocks of Cropland were estimated on the basis of IPCC default values due to the insignificant share of this land-use category in Singapore. The default soil C stock and management factors for cropland were taken from the 2006 IPCC Guidelines.

Subsequent to the 2nd BUR, a series of significant enhancements was carried out in the LULUCF sector which had a significant impact on the change in the emission trends of this report compared to the results presented in the 2nd BUR of Singapore. The most significant enhancements or refinements were:

1) The revision of the tree biomass growth rate of the Settlement subcategories based on new measurement data (the growth rate is now about one quarter of the figure used in the previous BUR), which led to a shift of the overall LULUCF time series from sinks towards emissions.

2) For the 3rd BUR, the land use, land-use change and conversion areas were analysed on the basis of satellite images for each year of the time series, while for the 2nd BUR the time series was interpolated for intermediate years. Therefore, the 3rd BUR results show significant variations across the time series compared to the rather stable trends presented in the 2nd BUR.

Due to the revisions explained above, the emissions/removals of the LULUCF sector are oscillating across the time series from 1990 to 2014, mainly caused by the dynamics in the Settlements category. The total annual net emissions for the reporting year 2014 for the LULUCF sector of Singapore amounted to 62.03 Gg CO_2eq (including N_2O). A summary breakdown of the contributions from each land-use category is represented below.

Land-Use Category	Annual Change in carbon stocks, Gg CO_2				CH_4 (Gg CO_2e)	N_2O (Gg CO_2e)
	Living Biomass A	Dead Organic Matter B	Soils C	CO_2 removals/ emissions D=A+B+C		
Forest Land	-46.15	-4.29	-7.91	-58.34	NO	0.00
Cropland	2.92	0.64	-0.47	3.09	NO	0.00
Grassland	NO	NO	NO	NO	NO	NO
Wetlands	1.16	0.17	1.40	2.73	NO	NO
Settlements	55.65	12.30	38.21	106.16	NO	8.39
Other	0.00	0.00	0.00	0.01	NO	NO
TOTAL	**13.59**	**8.81**	**31.24**	**53.64***	**NO**	**8.39***

**Note: Figures including additions may not tally due to rounding difference*

Key Category Analysis

The 2006 IPCC Guidelines for 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 9th and 13th key category. The 9th category refers to emissions of PFCs, namely used and emitted by companies which manufacture semiconductors and integrated circuits, while the 13th category refers to emissions of HFCs, mainly used in Solvents. The main contributor to GHG emissions is CO_2 emissions from the combustion of natural gas (33.3%) to generate electricity.

Key Category Analysis						
	IPCC Category		Type of Greenhouse Gas	Emissions (Gg CO_2e)	Percentage Contribution	Cumulative
1	Energy and Transformation Industries	Natural Gas	CO_2	16,964.45	33.32%	33.32%
2	Industry	Refinery Gas	CO_2	11,088.09	21.78%	55.10%
3	Industry	Natural Gas	CO_2	4,526.34	8.89%	63.99%
4	Land Transport	Diesel	CO_2	4,174.56	8.20%	72.19%
5	Industry	Fuel Oil	CO_2	2,554.82	5.02%	77.21%
6	Land Transport	Petrol	CO_2	2,253.29	4.43%	81.64%
7	Energy and Transformation Industries	Municipal Solid Waste[26]	CO_2	1,570.76	3.09%	84.73%
8	Industry	Diesel	CO_2	1,567.79	3.08%	87.81%
9	Industrial Processes and Product Use	Electronics Industry	PFCs	1,146.83	2.25%	90.06%
10	Industry (Fugitive Emissions)	Oil and Natural Gas Systems	CO_2	943.58	1.85%	91.91%
11	Energy and Transformation Industries	Coal	CO_2	896.68	1.76%	93.67%
12	Industry	Petroleum Coke[27]	CO_2	540.17	1.06%	94.73%
13	Industrial Processes and Product Use	Product Uses as Substitutes for Ozone Depleting Substances	HFCs	249.06	0.49%	95.22%

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

[27] Emissions from the combustion of Liquefied Petroleum Gases (LPG) and Gas Works Gas under the Industry sector are included here due to data confidentiality.

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.

99.6% of GHG data has a confidence level of either "medium" or "high". A large proportion of these emissions are from fuel combustion. The collection of fuel combustion and IPPU 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 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 categories 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 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. As the GHG emissions from the LULUCF sector are based on subtractions between emissions and removals in pools, subcategories and across subcategories, this leads to a relatively high uncertainty even when highest tier approaches are applied (as in the case of Singapore). The highly dynamic Settlements subcategories and the subcategory land-use change to Forest Land contribute most to the total uncertainty of the LULUCF sector.

Confidence Levels of Data		
Greenhouse Gas Source and Sink Categories	**Confidence Level**	**% of Total GHG Emissions**
All Energy		**95.14%**
Fuel Combustion		
Energy and transformation industries	H	38.49%
Industry	M	39.88%
Transport	M	13.56%
Commercial-institutional	H	0.84%
Residential	H	0.41%
Fugitive fuel emission		
Oil and natural gas systems	H	1.96%
Industrial Processes & Product Use		**4.11%**
Industrial Processes & Product Use	H	4.11%
Land Use, Land-Use Change and Forestry		**0.12%**
Land Use, Land-Use Change and Forestry	L	0.12%
Waste		**0.63%**
Wastewater handling	L	0.24%
Hazardous waste incineration	H	0.39%
Clinical waste incineration	H	~0.00%

Time Series of Greenhouse Gas Emissions (2000-2014)

The time series of Singapore's national inventory from 2000 to 2014 is prepared in a consistent manner following the methodologies outlined and is as shown below.

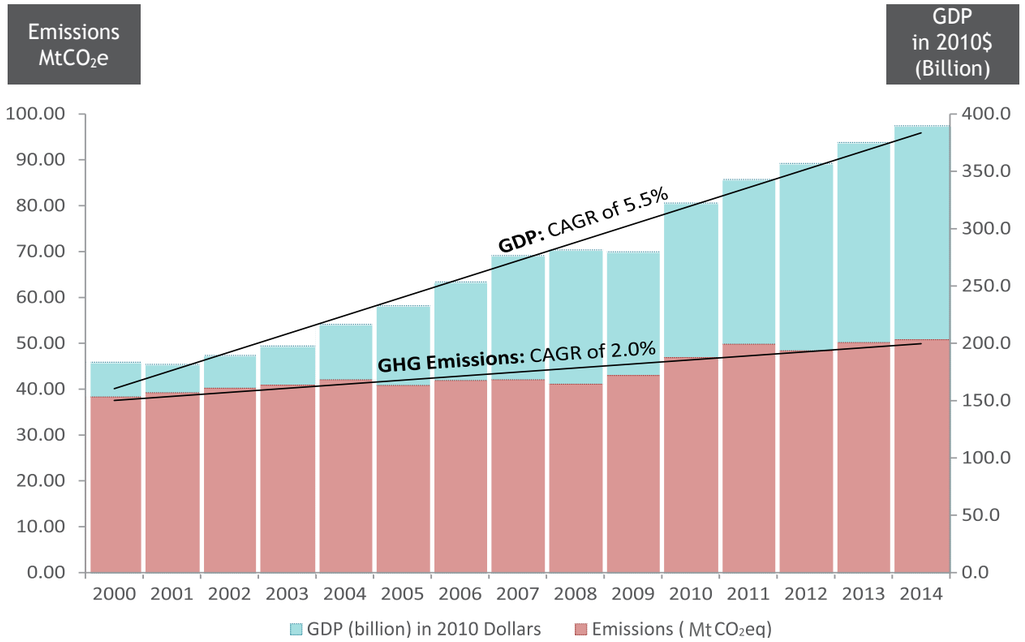
From 2000 to 2014, Singapore's economy grew at a compounded annual growth rate (CAGR) of 5.5%, while real GDP levels (in 2010 dollars) increased by 112% from S$183 billion in 2000 to S$390 billion in 2014. In the same period, Singapore's GHG emissions grew at a slower rate with a CAGR of 2.0%, and an increase of 32.8% (12,579 Gg CO_2-equivalent) from 2000 to 2014.

As an open trade-oriented economy, Singapore's GDP growth volatility is much higher than that of larger economies.[28] 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.

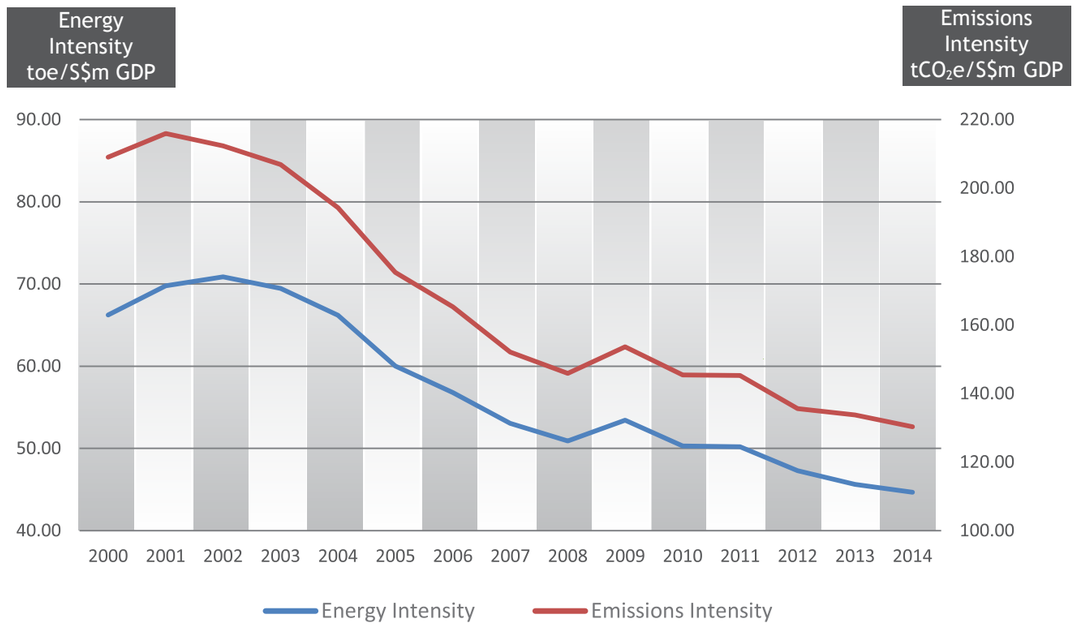
Overall, emissions intensity decreased by 37% from 2000 to 2014 while energy intensity decreased by 33%. Some of the key policy initiatives implemented during this period included a switch in fuel mix from fuel oil to natural gas which is a cleaner fuel source, as well as introducing various schemes promoting energy efficiency throughout the decade, such as the Green Mark Scheme for buildings, and the Grant for Energy Efficient Technologies (GREET) for industry.

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

Time Series of Greenhouse Gas Emissions

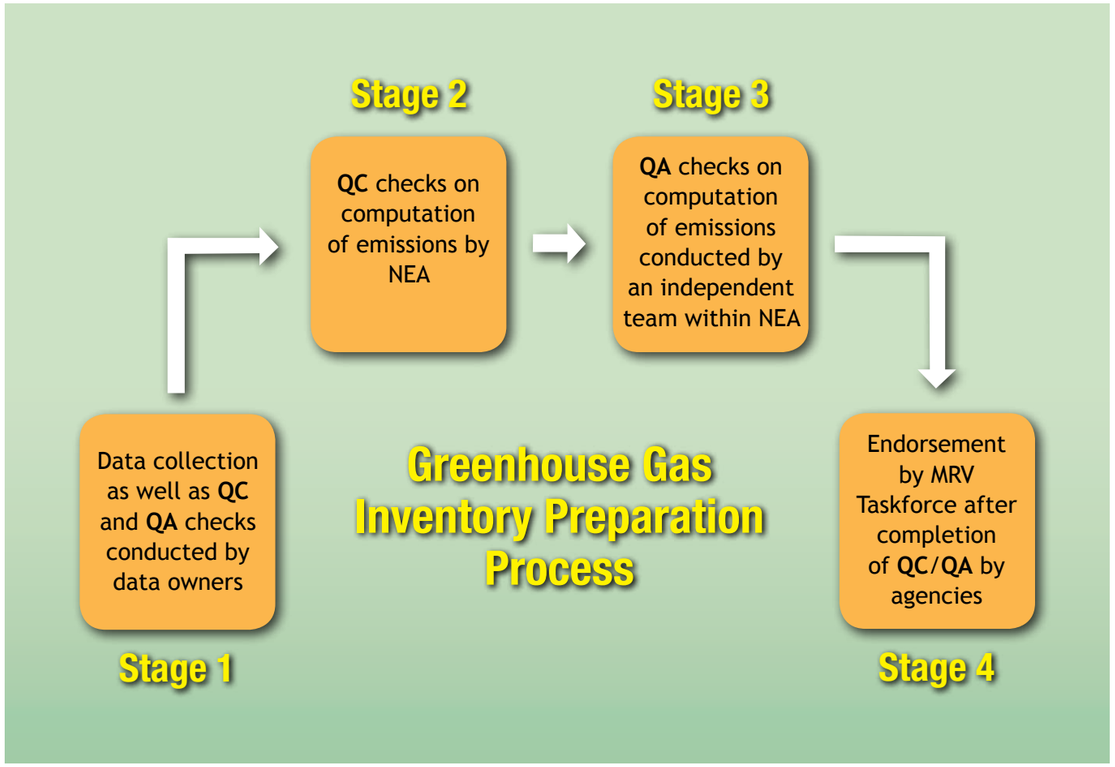


Time Series of Energy and Emissions Intensity



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.



QC | Quality Control QA | Quality Assurance

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-institutional		Department of Statistics Energy Market Authority
Residential		Department of Statistics Energy Market Authority
Industrial Processes & Product Use	**CO_2, CH_4, N_2O, HFCs, PFCs, SF_6**	**National Environment Agency**
Land Use, Land-Use Change and Forestry	**CO_2, N_2O**	**National Parks Board**
Waste		
Waste Incineration[29]	CO_2, CH_4, 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)
Hazardous and Clinical Waste Incineration	CO_2, CH_4, N_2O	National Environment Agency

An Emissions Data Monitoring and Analysis (EDMA) system has been developed to facilitate the inventory compilation process. The system has been 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 data base.

[29] According to the IPCC Guidelines, CO_2, CH_4 and N_2O emissions from waste incineration are reported in the Energy sector.

The system has been 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 include archival and storage of past activity data and emissions 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.

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.

Quality checks have also been incorporated into the EDMA system. These include checks on the acceptable range of data input and factors, as well as percentage differences compared to emissions from previous years.

	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 GHG 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 GHG 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.

Singapore's participation in the 16th Workshop on Greenhouse Gas Inventories in Asia (WGIA16) held in New Delhi, India 2018.

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.

CHAPTER 4

MITIGATION MEASURES

> Energy is a strategic resource for Singapore as we are almost completely reliant on the import of oil and gas for our energy needs.

Among the alternative energy options available to Singapore, solar energy offers the most promising opportunity for Singapore.

CHAPTER 4
MITIGATION MEASURES

The Singapore Sustainability Academy is the first major People, Private and Public (3P) ground-up initiative in support of climate action, the UN Sustainable Development Goals and Singapore's national goals to tackle climate change. It is also the first collaboration between a private developer, City Developments Limited (CDL) and a non-profit organisation, Sustainable Energy Association of Singapore (SEAS) harnessing their combined expertise and extensive network to set up a major capacity building and networking platform. The zero-energy academy is constructed using Cross Laminated Timber (CLT) and Glued Laminated Timber (Glulam) verified by the Nature's BarcodeTM system as coming from responsible sources, which help to achieve both environmental sustainability and construction productivity. The Singapore Sustainability Academy is a recipient of the BCA Green Mark Platinum Award 2016.

Building Owner	City Developments Limited
Architect	ONG&ONG
M&E Consultant	Rankine&Hill
ESD Consultant	Building System & Diagnostic Pte Ltd

Introduction

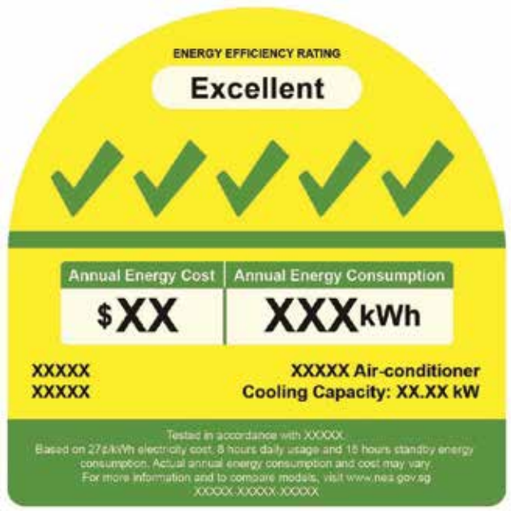
Under our 2009 Copenhagen pledge, Singapore is committed to reduce emissions by 16% below 2020 business-as-usual (BAU) levels. Having ratified the Paris Agreement on 21 September 2016, Singapore has also formalised our 2030 pledge which builds on our 2020 commitment. As stated in our Nationally Determined Contribution (NDC), Singapore aims to reduce our Emissions Intensity by 36% from 2005 levels by 2030, and stabilise our emissions with the aim of peaking around 2030. While these are challenging targets given our limited potential for alternative energy sources that could reduce emissions on a significant scale, Singapore is well on track to meet our 2020 pledge.

Singapore's Approach to Reducing Emissions

Energy is a strategic resource for Singapore as we are almost completely reliant on the import 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 also do not subsidise energy costs. This policy of pricing energy correctly helps to incentivise firms and households to use energy wisely, minimising energy wastage and over-consumption, thus helping to control emissions.

Since early 2000s, Singapore has taken steps to use a cleaner fuel mix for electricity generation, switching from fuel oil to natural gas. However, there are limits to how much more emissions can be reduced by switching fuels, as natural gas currently constitutes about 95% of our fuel mix for electricity generation. 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 options for alternative energy sources, improving energy efficiency is one of our key 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, greater energy efficiency also leads to cost savings. The Singapore Government will continue to raise awareness and build capabilities to improve energy efficiency across sectors. A major part of this effort involves addressing sector-specific barriers using incentives or regulatory measures where appropriate.



The Mandatory Energy Labelling Scheme for Appliances was introduced in 2008 to raise consumer awareness of the energy consumption of various household appliances.

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 around 95% in 2016. 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.

Traditionally, Singapore has relied heavily on natural gas piped from Malaysia and Indonesia for power generation. Since May 2013, Singapore has imported liquefied natural gas (LNG) from global gas markets through our LNG terminal. Having access to both LNG and piped natural gas has helped to diversify and secure our energy sources and further increase the share of clean natural gas in our fuel mix.

We are exploring ways to increase our use of solar energy. Among the renewable energy options, solar energy remains the most promising option for Singapore. While the amount of solar panels installed in Singapore is still small, its deployment has been growing steadily. As at end 2017, Singapore has 145.8 MWp of solar photovoltaics (PV) installed, compared to 15.3 MWp in 2013. For solar energy to be adopted at scale, consumers ultimately have to find it cost-competitive vis-à-vis the electricity which they can buy from the grid. We are actively investing in R&D and test-bedding to improve the efficiency and lower the price of solar technologies for adoption on a larger scale.

To facilitate this, the Economic Development Board (EDB) had previously implemented solar capability building schemes such as the Solar Capability Scheme (SCS) and Clean Energy Research Testbedding (CERT). These had built up capabilities among our local solar companies in the engineering design and installation of solar PV systems, and also developed capabilities in our research institutes in solar PV materials and manufacturing. Moving forward, Singapore will continue to invest in R&D to improve solar PV cell efficiencies and module power, and to also develop system capabilities so that the cost of installing solar can be lowered. On the demand side, the government embarked on the SolarNova programme which aggregates demand for solar PV deployment across public sector buildings and spaces, to catalyse the growth of the solar industry in Singapore. Currently, 3 tenders totaling 166 MWp have been awarded, with a fourth tender to be called in 2019. The SolarNova programme forms part of Singapore's plan to reach 350 MWp of installed solar PV capacity by 2020. Other approaches to further push the envelope for solar deployment include floating PV.

PUB, Singapore's National Water Agency launched a floating solar PV testbed at Tengeh Reservoir in October 2016. Building on this, PUB has plans for floating solar projects at reservoirs like Bedok, Lower Seletar, Tengeh and Upper Peirce. In particular, Tengeh Reservoir offers an ideal rollout location for large scale solar of 50 MWp. The amount of energy generated from the 4 reservoirs can potentially power about 15,000 4-room HDB homes.

Floating Solar PV testbed at Tengeh Reservoir.

In addition, the Energy Market Authority (EMA) has been enhancing the market and regulatory framework to facilitate solar deployment in a sustainable manner. Some of the key enhancements include providing greater clarity on the licensing framework for solar and streamlining market registration and settlement procedures. EMA will continue to work with the industry to facilitate greater deployment of solar in the power system.

These measures to shift Singapore to cleaner energy sources are projected to achieve 4.18 Mt of CO_2e abatement by 2020, with an estimated 4.05 Mt of CO_2e abatement in 2016.

Measure #2: Improving Industrial Energy Efficiency

As industry is the largest energy-consuming sector in Singapore, improving industrial energy efficiency is key to reducing our emissions. In 2014, our energy intensity was 44.5 ktoe/S$ billion or 60.5 ktoe/US$ billion.[30] This compares favourably globally and has been achieved with the help of schemes introduced by the Government to overcome market barriers to the adoption of energy efficient practices, such as limited capital, split incentives, bounded rationality and lack of information.

The Singapore Government is committed to encouraging the industry to adopt energy efficient technologies through grants, private sector financing schemes and tax incentives.

Examples of these schemes included the Grant for Energy Efficiency Technologies (GREET),[31] which offsets part of the initial capital investments in energy efficient technologies, and the Energy Efficiency Improvement Assistance Scheme (EASe), which provides co-funding for companies to conduct energy assessments and identify potential areas for energy efficiency improvements. An energy efficiency financing scheme was also launched in 2014 to further address the market barrier of high upfront costs of energy efficiency. In 2017, the EASe and other existing incentive schemes administered by the NEA were consolidated to form the new Energy Efficiency Fund (E2F) to better support a range of energy efficiency efforts, from energy efficient design of new facilities, energy assessments of existing facilities, to energy efficient technologies investment. To develop and build up expertise in energy efficiency, Singapore has also conducted energy efficiency studies and put in place national schemes for building energy efficiency capabilities within our workforce.

The Energy Conservation Act (ECA), introduced in 2013, mandates energy-intensive companies in the industrial sector to appoint a qualified energy manager, monitor and report their energy use and GHG emissions, and submit energy efficiency improvement plans on an annual basis. The ECA has since been further enhanced. With effect from 2018, companies regulated under the ECA are required to adopt specified methodologies for GHG measurement and reporting, in line with best practices and internationally recognised standards. Companies investing in new and major expansions of energy-intensive industrial facilities are required to review the facility design to identify technically and economically feasible energy efficiency improvement opportunities. These companies must also report measured energy performance of key energy-consuming systems in their facilities. From 2021, companies regulated under the ECA will be required to put in place a structured energy management system, and periodically assess energy efficiency opportunities at existing industrial facilities. In addition, minimum energy performance standards will be introduced to phase out the least efficient industrial electric motors in late 2018, and expanded to other common industrial equipment and systems thereafter.

Overall, we expect to achieve 1.43 Mt of CO_2e abatement from these energy efficiency measures by 2020, with an estimated 1.27 Mt of CO_2e abatement in 2016.

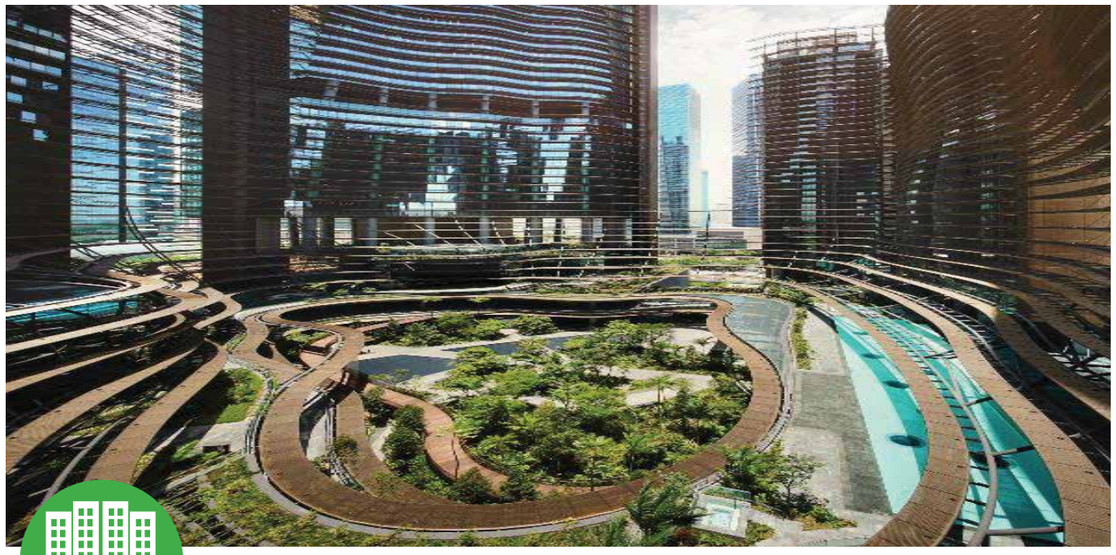
[30] Figures cited are calculated from domestic data sources. Conversion from SGD to USD is based on exchange rates as of June 2018.

[31] The scheme has been replaced with the Productivity Grant for Energy Efficiency since 2016.

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, a national energy efficiency yard stick 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.

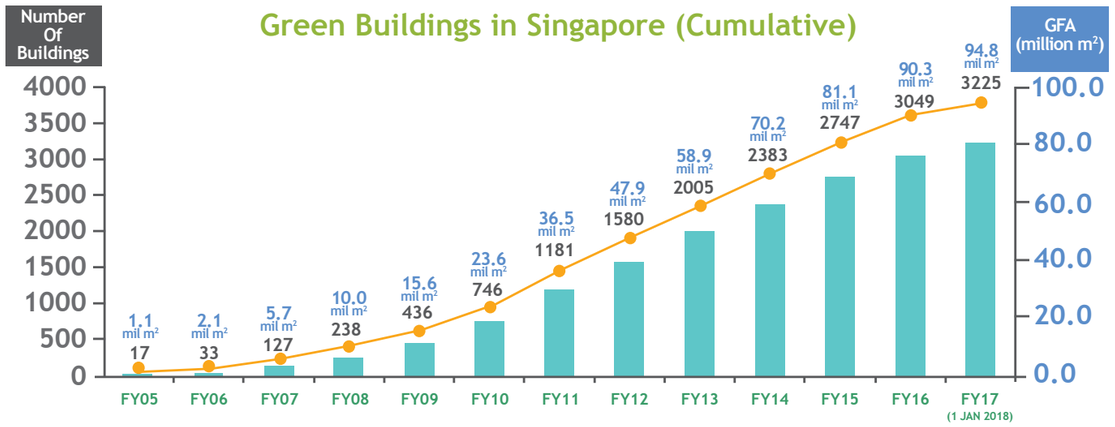


Marina One is a recipient of the BCA Green Mark Platinum Award 2012 and the MIPIM Award 2018 for the Best Innovative Green Building.

Building Owner	M+S Pte Ltd
Architect	Architect 61 Pte Ltd and Ingenhoven Architects
M&E Consultant	Beca Carter Hollings & Ferner (SE Asia) Pte Ltd
ESD Consultant	Beca Carter Hollings & Ferner (SE Asia) Pte Ltd

The Singapore Government has employed both regulation and incentives to drive the green building movement. 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 prescribed buildings[32] are required to submit building information and energy consumption data annually. Starting this year, the information from commercial buildings, healthcare facilities and educational institutions are publicly disclosed to encourage buildings to consciously adopt measures to reduce their energy footprint. In addition, existing office, hotel and retail buildings with gross floor area of more than 15,000 square meters have to achieve minimum Green Mark standards when a cooling system is installed or retrofitted and carry out three-yearly energy audits on building cooling systems. Regulation is complemented with incentives and financing schemes, such as the $50 million Green Mark Incentive Scheme for Existing Buildings and Premises (GMIS-EBP) and Building Retrofit Energy Efficiency Financing (BREEF) scheme, for developers to achieve higher-tier Green Mark ratings, and to assist building owners in financing the high upfront retrofitting cost. We are aiming for at least 80% of the total gross floor area in Singapore to achieve Green Buildings standard by 2030, compared to more than 34% as of 1 Jan 2018.

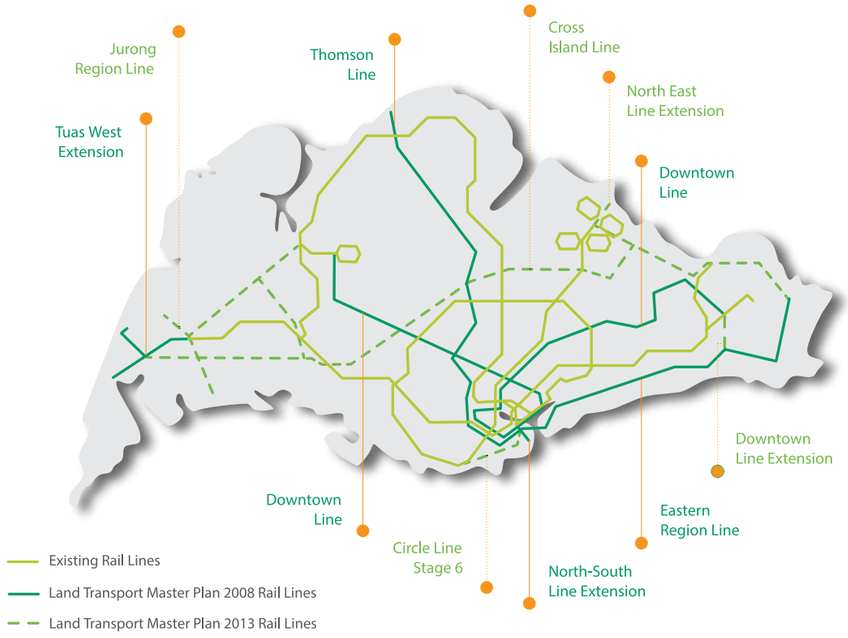
The mitigation measures in the building sector are projected to achieve 0.87 – 1.55 Mt of CO_2e abatement by 2020, with an estimated 0.846 Mt of CO_2e abatement in 2016.



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

Public transport is the most energy efficient mode of powered transport. Singapore's target is for the public transport modal share during the morning and evening peak hours to reach 70% by 2020 and 75% by 2030, up from 59% in 2008 and 67% in 2017. To encourage the use of public transport, the length of the rail network will increase from 230km today to about 360km by 2030. This will enable 8 in 10 households to be within a ten-minute walk of a train station, and 85% of public transport journeys of less than 20km to be completed within 60 minutes. To enhance Singapore's public transport connectivity, 1,000 new buses and 80 new bus services were added to our bus network between 2012 and 2017.

[32] Building types include commercial buildings (offices, hotels, retail buildings and mixed developments), healthcare facilities, education institutions, civic and community institutions, places of worship and sport and recreation, transport facility and light industrial buildings.



The Singapore Government is also encouraging the use of cycling and walking for short distance trips. Today, cycling networks in nine public housing towns and 200km of sheltered walkways island-wide have been built. The aim is to provide a cycling path network in every public housing town, and an island-wide off-road cycling path network of over 700 kilometres by 2030.

To reduce reliance on private transport, the ownership and usage of private cars will continue to be managed through various taxes as well as fees and charges that reflect the competing needs for our scarce land. Prospective car vehicle owners are required to bid and pay for a limited pool of Certificates of Entitlement, which allows a holder to purchase a vehicle and use it for 10 years. Since February 2018, the permissible growth rate of private vehicle population has been reduced to zero per cent, from 0.25%, effectively capping the growth of private vehicles. Through the Electronic Road Pricing system, all vehicles have to pay a charge for using congested roads during peak hours throughout the year to manage car usage.

To encourage the use of vehicles with lower emissions, the Carbon Emissions-based Vehicle Scheme (CEVS) and the Fuel Economy Labelling Scheme (FELS) were introduced in 2013. The FELS provides information on the fuel economy of vehicles for more informed decision on vehicle purchase, while the CEVS provides rebates for low-emission cars and imposes surcharges on high-emission cars. The CEVS was replaced by the Vehicular Emissions Scheme (VES) with a new Vehicular Emissions label in January 2018. In addition to carbon dioxide (CO_2), the VES includes four additional pollutants (hydrocarbons, carbon monoxide, nitrogen oxides, and particulate matter) in the assessment of new cars, taxis and newly imported used cars for rebate or surcharge based on the worst-performing pollutant.

Various trials are underway to assess the use of electric vehicles in Singapore. In December 2017, Singapore rolled out an electric car-sharing programme, which will introduce 1,000 shared electric cars and 2,000 charging kiosks island-wide by 2020. In addition, 50 hybrid buses and 60 electric buses will be deployed by the first quarter of 2019 and mid-2020 respectively for trials.

Overall, the mitigation measures in the transport sector are projected to achieve 1.64 – 1.68 Mt of CO_2e abatement by 2020, with an estimated 0.90 Mt of CO_2e abatement in 2016.

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

The household sector accounts for about 16% of the total electricity consumption in Singapore. To improve energy efficiency in households, the Singapore Government implemented the Mandatory Energy Labelling Scheme (MELS) for energy intensive appliances. MELS provides information on the energy efficiency performance of different appliances. This empowers households to make better purchasing decisions. Since January 2008, regulated goods must carry the energy label under the ECA. To date, MELS has been implemented for air-conditioners, refrigerators, TVs, clothes dryers and lamps. In September 2014, the energy tick ratings on energy labels were improved to help consumers better differentiate the energy efficiency of various models and 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 raises the average energy efficiency of household appliances by removing energy inefficient appliance models from the market. Only appliance models that meet minimum energy efficiency standards are allowed for sale. This protects consumers from being locked into the high energy costs of operating energy inefficient appliances. MEPS for air-conditioners and refrigerators were raised in 2016 and 2017 respectively. MEPS were also extended to clothes dryers on 1 Apr 2014 and lamps[33] on 1 Jul 2015.

In 2017, the Singapore Government organized "The Energy-Saving Challenge" to encourage households to be more energy efficient and practise energy-saving habits. The Challenge received close to 7,000 entries and participants saved a total of 330,000 kWh, enough to power 830 units of four-room flats for more than a month.

Mandatory Energy Labelling Scheme.

The mitigation measures in the household sector are projected to achieve about 0.71 – 1.07 Mt of CO_2e abatement by 2020, with an estimated 0.57 Mt of CO_2e abatement achieved in 2016.

[33] This covers incandescent lamps, compact fluorescent lamps with integrated ballasts (CFLi) and direct LED replacement lamps used for general lighting purposes.

Measure #6: Reducing Emissions from Waste and Wastewater Treatment

The Singapore Government is also looking to reduce emissions from the waste and water 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. Our overall recycling rate was 61% in 2017.

Other measures to reduce emissions are through better energy management such as maximising energy efficiency in operations and increasing energy production and recovery. One key initiative that is in progress is the co-location of a used water treatment plant (i.e. Tuas Water Reclamation Plant (TWRP)) and an Integrated Waste Management Facility (IWMF) which is expected to be completed by 2027. The integration of these two facilities provides an opportunity to harness synergies and reap the benefits of a Water-Energy-Waste nexus. The IWMF can, for instance, tap on TWRP's treated used water for its processes, and supply food waste to TWRP to help generate more biogas and electricity. This will lead to a much higher overall energy efficiency and recovery.

We project the mitigation measures in the waste and water sectors to achieve 0.15 Mt of CO_2e abatement by 2020, with an estimated 0.12 Mt of CO_2e abatement in 2016.

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 GHG emission reductions from registered projects implemented in non-Annex I Parties to earn certified emission reductions (CER) credits, which could be used to offset emissions of Annex I Parties.

As of September 2018, Singapore has six registered CDM projects.

Information on the six registered CDM projects was reported earlier in Singapore's Third National Communication and First Biennial Update Report.

Ngee Ann City is a success case study of an existing commercial mixed development undergoing deep energy retrofits to achieve the highest accolade for BCA Green Mark Platinum Award in 2015.

Building Owner	The Management Corporation Strata Title Plan No. 2929
EPC/ESCO firm	Comfort Management Pte Ltd
Facility Management	Ngee Ann Property Management Pte Ltd

Carbon Tax

From 2019, Singapore will implement a carbon tax starting at S$5 per tonne of CO_2-equivalent (tCO_2e) of greenhouse gas (GHG) emissions in the first instance, between 2019 and 2023, as a transition period. We intend to increase it to S$10-15/$tCO_2e$ by 2030. The carbon tax will cover around 80% of our national emissions, and will be applied uniformly to large emitters[34] across all sectors, without exemption. The carbon tax puts in place an economy-wide price signal to encourage GHG emissions reductions where it makes the most economic sense. The carbon tax will complement our existing mitigation efforts to meet our climate pledge under the Paris Agreement.

Domestic Measurement, Reporting and Verification

The domestic measurement, reporting and verification (dMRV) of Singapore's mitigation actions is a whole-of-government effort.[35] Each government agency is responsible for monitoring, measuring and documenting the progress of the mitigation actions under its purview.

Agencies usually utilise relevant data collected from official surveys, required under various Acts, for dMRV purposes. Data collected from companies and/or building owners are then verified by the lead agencies. For example, power generation companies are required under the Electricity Act to measure and report the quantity of fuel used for electricity generation monthly. The lead agency for the power sector, Energy Market Authority (EMA), will verify the reported data through QA/QC procedures in accordance with the International Energy Agency (IEA), Intergovernmental Panel on Climate Change (IPCC) and United Nations Statistics Division's guidelines and requirements. EMA uses these data to monitor emissions from the electricity generation sector. The aggregated data is also available through EMA's annual "Singapore Energy Statistics" report.

Information collected by the lead agencies is consolidated by the Long Term Emissions and Mitigation Working Group (LWG) secretariat annually. LWG will then assess the effect of the various mitigation measures and track Singapore's progress in meeting our mitigation pledge and objectives.

Ng Teng Fong Hospital received the BCA Green Mark Platinum Award in 2012 and the Asean Energy Award in 2017 for Energy Efficient Building (New and Existing Building).

Building Owner	Ministry of Health
Architect	CPG Consultants
M&E Consultant	Parsons Brinckerhoff Pte Ltd
ESD Consultant	ZEB Technology Pte Ltd

[34] With annual emissions of 25 kt CO_2e and above.

[35] The agencies involved include the Ministry of the Environment and Water Resources, 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.

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.	**Completed** 4Mt of abatement has been achieved due to the increase in the share of natural gas in the generation mix from approximately 70% in the BAU case to 95%. Since 2005, the power generation industry's repowering to natural gas, the introduction of the LNG terminal and LNG vesting has contributed to the increase in the share of natural gas to 95% in 2016.	Infrastructure development	4.0	Natural gas is expected to form more than 90% of Singapore's fuel mix for power generation in 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 95% in 2016. Estimated abatement achieved in 2016: 4.0Mt
Solar installation from existing schemes	To facilitate the adoption of solar Photovoltaics (PVs).	Encouraging more R&D, test-bedding and deployment of solar PV.	**Ongoing** Overall, Singapore plans to raise the adoption of solar power in our system to 350 mega-watt peak (MWp) by 2020. The whole-of-Government effort to facilitate solar adoption includes capability development, such as HDB's solar capability building programme for public housing; multi-agency solar-leasing tenders; and 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. EDB also launched the SolarNova programme, which aims to accelerate solar deployment in Singapore by promoting and aggregating solar demand across government building and spaces.	Incentive, Technology	0.179	The carbon abatement achieved by this measure is based on the emissions from Combined Cycle Gas Turbines (CCGTs) that would have resulted from generating the amount of electricity displaced by solar.	CO_2	Installed Solar Capacity.	Estimated abatement achieved in 2016: 0.047Mt

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
Co-generation plants	To encourage investment in co-generation plants.	Encouraging co-generation plant investments, which will reduce carbon emissions through increasing energy efficiency in electricity and steam generation, through the provision of incentives to encourage companies to improve their energy efficiency.	**Ongoing** Three co-generation plants have been constructed with an estimated 614ktpa of abatement. A fourth co-generation plant is expected to be constructed in the period 2018-2020.	Incentive	0.67-0.73	0.67-0.73Mt of carbon mitigation by 2020 is assumed to be delivered by 3 to 4 co-generation plants in the petroleum and petrochemical sector. Carbon mitigation achieved per co-generation plant is based on technical estimates and information provided by companies. As part of the application process for incentives, companies are required to report the carbon abatement resulting from their investments. Verification checks are done by Professional Engineers, Singapore Certified Energy Managers or Qualified Energy Services Specialists after project completion.	CO_2	Number of co-generation plants, total funding given out, abatement achieved calculated through data collection/ audits.	Estimated abatement achieved in 2016: 0.614Mt
Manufacturing Energy Efficiency	To encourage energy efficiency and consequently reduce emissions from the manufacturing sector.	Encouraging energy efficiency retrofits in the manufacturing sector through incentives, and private sector financing of energy efficiency projects.	**Ongoing** 586ktpa 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). In 2017, the EASe and other existing incentive schemes were consolidated to form the new Energy Efficiency Fund (E2F) to better support a range of energy efficiency efforts.	Incentive	0.31 – 0.59	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 2016: 0.586Mt
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 carbon abatement achieved from the displacement of existing fuel by use of cleaner fuel types.	CO_2	Abatement achieved calculated through data collection/ audits.	Estimated abatement achieved in 2016: 0.07Mt
Data Centre EE	To encourage energy efficiency and consequently reduce emissions from data centres.	Encouraging energy efficiency retrofits in data centres through incentives.	**Ongoing** Since 2012, investment allowances have been made available to green Data Centres (DCs).	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 needs to that of all Information and Communications Technology (ICT) equipment.	CO_2	Power Usage Effectiveness of Data Centres.	Estimated abatement achieved in 2016: 0.000283 Mt

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 buildings	To improve energy efficiency of new and existing buildings.	New Buildings Legislating new building owners to achieve minimum Green Mark (GM) standard and incentivising building owners 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. Existing Buildings Legislating existing building owners to improve the energy efficiency of their facilities when undergoing major retrofits to achieve minimum GM standards and incentivising building owners to achieve GM rating beyond the minimum standard through fiscal measures.	**Ongoing** New Buildings 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 government land sales conditions for certain areas, e.g. Marina Bay, Jurong Lake. The $20mil Green Mark Incentive Scheme (fully committed) and Green Mark Gross Floor Area Incentive Scheme have also been introduced to encourage greater efficiency in new buildings. As of 1st Jan 2018, there were more than 3,200 new and existing buildings that have met the Green Buildings standard, accounting for more than 34% of total gross floor area in Singapore. Existing Buildings Since 2012, existing buildings have been required by legislation to achieve minimum Green Mark (GM) standard when they undergo major retrofits. In addition, existing prescribed buildings are required to submit building energy consumption annually. Prescribed building types are also required to submit energy audits on building-cooling systems every 3 years. To incentivise further energy efficiency improvements in existing buildings, $100 million has been set aside to co-fund up to 50% (capped at $3mil) of energy efficiency investments for existing buildings (upgrading and retrofitting components have been fully committed) and a Building Retrofit Energy Efficiency Financing (BREEF) scheme was also introduced to provide financing options to building owners, to address the high upfront costs required.	Legislation and Incentives	0.87 – 1.55	The target abatement is calculated by the difference between the BAU emission values (i.e. no legislation/ incentives) projected for the new and existing building stock in 2020, and the emission values after legislation and incentives have been implemented.	CO_2	Through electricity consumption and building information data collected using the Building Energy Submission System (BESS).	Estimated abatement achieved in 2016: 0.846Mt

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 powered transport.	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 length of the rail network will increase from 230km today to about 360km by 2030. Singapore's target is for the public transport modal share during the morning and evening peak hours to reach 70% by 2020 and 75% by 2030, up from 59% in 2008 and 67% in 2017.	Combination of infrastructure, regulations, incentives, technology and education	0.78	Mitigation effect of public transport modal split is calculated as the difference between the total energy consumed for (i) the projected BAU travel demand and the modal split and; (ii) the actual travel demand and the modal split.	CO_2	Public transport modal share.	Estimated abatement achieved in 2016: 0.59Mt
Promoting Off-Peak Cars (OPC) and non-motorised transport, e.g. walking and cycling	To reduce reliance on cars as a means of transport.	Implementing schemes that limit use of cars to off-peak periods, and rolling out various initiatives that encourage walking and cycling.	**Ongoing** Today, 200km of sheltered walkways, and cycling networks in nine public housing towns have been built. The aim is to provide a cycling path network in every public housing town, and an island-wide off-road cycling path network of over 700 kilometres by 2030.	Combination of infrastructure, incentives and education	0.16-0.20	Abatement calculated based on the number of off-peak cars and the difference between the average carbon emissions of a normal car compared to those of an OPC. This is calculated against BAU projections which does not include the roll out of such an OPC scheme.	CO_2	OPC take-up rate.	Estimated abatement achieved in 2016: 0.085Mt
Car/Taxi fuel efficiency – CEVS/ VES	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)/Vehicular Emissions Scheme (VES).	**Ongoing** The CEVS and the FELS were introduced in 2013. The CEVS was replaced by the VES with a new Vehicular Emissions label in January 2018. In addition to carbon dioxide (CO_2), the VES includes four additional pollutants (hydrocarbons, carbon monoxide, nitrogen oxides, and particulate matter) in the assessment of new cars, taxis and newly imported used cars for rebate or surcharge based on the worst-performing pollutant.	Legislation and Incentive	0.60	Mitigation effect of CEVS/ VES is calculated based on the increased quantity of cars/taxis purchased in the lower carbon bands (i.e. the rebate bands or cars that are cleaner), compared to the historical rates, and the average carbon emission reduction between the CEVS/ VES bands. This is calculated against BAU projections, which are based on the emissions computation considering purchase of cars/taxis in the absence of CEVS/VES rebates/surcharges.	CO_2	Increase in registration of cars in lower carbon bands and reduction in registration of cars in the higher carbon bands.	Estimated abatement achieved in 2016: 0.17Mt
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 like terminal operations, ship owning and/or operations and harbour craft operations to co-fund the development and adoption of green technological solutions.	**Ongoing** Projects approved by the Green Technology Programme are ongoing. When completed, a review will be conducted to determine whether the green technologies adopted under this programme can be successfully implemented on a larger scale.	Incentive	0.10 (subject to review based on take-up rates of projects)	Abatement will be calculated based on specific information from each project and monitored for take-ups. This is calculated against BAU projections (i.e. no GTP).	CO_2, SO_X, NO_X	Take-up rates of various programmes.	Estimated abatement achieved in 2016: 0.055Mt

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 – i.e. air-cons, fridges, lighting, clothes dryers	To improve the overall energy efficiency of appliances in the market.	Disallowing the supply of inefficient appliances that fall short of specified minimum energy efficiency levels.	**Ongoing** MEPS for air-conditioners and refrigerators were implemented in September 2011 and raised between 2013 and 2017 respectively. MEPS for clothes dryers were implemented in April 2014. MEPS for general lighting were implemented in July 2015.	Legislation	0.71-0.79	The carbon emissions arise from the energy use of home appliances. The emissions in two scenarios are calculated, the BAU and the Policy scenarios. In both scenarios, the annual hours of usage of home appliances is assumed to remain the same as that of the reference year, 2005. In the BAU scenario, since there are no policies affecting purchasing decisions, it is assumed that there is no change in the purchasing pattern of home appliances by energy efficiency rating over the forecast period 2006 – 2020. The emissions are calculated based on the predicted stock of appliances (initial stock plus purchases less displaced and retired stock), annual hours of usage and annual energy consumption based on energy efficiency rating. In the Policy scenario, purchasing decisions are modified by mandated standards and energy labelling. The purchasing pattern of home appliances by energy efficiency rating is obtained from market data on purchases of products of different efficiency levels. This together with estimated lifespans of the appliances is used to calculate the mix of appliances by energy efficiency rating in the stock. The carbon emissions of the stock are calculated based on energy consumption. The emissions abatement is the difference in carbon emissions between the BAU and Policy scenarios.	CO_2	Annual purchase pattern of appliance models by tick-rating.	Estimated abatement achieved in 2016: 0.57Mt
Promotion of energy efficiency to households	To promote energy efficiency to households.	Promoting the purchase of energy efficient appliances through the Mandatory Energy Labelling Scheme (MELS) for household appliances and outreach efforts.	**Ongoing** MELS for air-conditioners and fridges were introduced in 2008 and extended to clothes dryers in 2009, televisions in 2014 and general lighting in 2015. Household energy efficiency awareness programmes (e.g. media publicity, energy-saving contests, energy efficiency roadshows) have been rolled out since 2008.	Promotion	0-0.28				*MEPS commenced in 2011.

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 of at landfills.	**Ongoing** Since 2009, ECO Special Waste Management and Sumitomo Mitsui Bank Corporation have been contracted to perform sludge incineration.	Infrastructure Development	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 (based on actual weight of sludge disposed at landfill site and ECO Special Waste Management).	CH_4	Amount of sludge incinerated.	Estimated abatement achieved in 2016: 0.09Mt
Increase overall recycling rate	To increase the overall recycling rate to 65% by 2020. The overall recycling rate in 2016 was 61%.	Mandatory waste reporting and submission of waste reduction plan for large commercial premises, starting with large hotels and shopping malls, has been implemented in 2014.	**Ongoing** Affected premises have submitted their waste report.	Legislation	0.05	Emissions and abatement will be calculated using the amount of waste incinerated and waste recycling rates, compared against the BAU projections.	CO_2, N_2O, CH_4	Recycling rate	Estimated abatement achieved in 2016: 0.03Mt
		Right waste disposal pricing.	Currently under evaluation.	Market-based instrument					

ANNEX TO THIRD BIENNIAL UPDATE REPORT

2014 Greenhouse Gas Inventory Worksheets Greenhouse Gas Summary Tables for 2012, 2010, 2000 and 1994

Upper Seletar Reservoir, one of the 17 reservoirs in Singapore.

> “ Singapore’s per capita domestic water consumption reduced from 165 litres per day in 2003 to 143 litres per day in 2017.

2014 GREENHOUSE GAS INVENTORY

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

COUNTRY: SINGAPORE YEAR: 2014

		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)	(tC / TJ)	(t C)	(Gg C)
Energy Industry							
Liquid Fuels							
Crude Oil	Kt						
Ethane	Kt						
Gas/Diesel Oil	Kt	23.73	43.33	1,028.38	20.20	20,773.30	20.77
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	3.51	40.19	141.05	21.10	2,976.05	2.98
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	345.43	28.00	9,672.10	25.80	249,540.08	249.54
Patent Fuel	Kt						
Peat	Kt						
Sub-Bituminous Coal	Kt						
Natural Gas							
Natural Gas (Dry)	Ktoe	7,258.91	41.868	303,916.17	15.30	4,649,917.39	4,649.92
Other Fossil-Based Fuels							
Industrial Waste	Kt						
Municipal Solid Waste	Kt						
Memo Items							
Gaseous Biomass	Kt						
Liquid Biomass	Kt						

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

COUNTRY: SINGAPORE YEAR: 2014

		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 Industry							**17,947.34**
Liquid Fuels							
Crude Oil	Kt						
Ethane	Kt						
Gas/Diesel Oil	Kt	0	0	20.77	0.990	20.57	75.41
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	2.98	0.990	2.95	10.80
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	0	0	249.54	0.980	244.55	896.68
Patent Fuel	Kt						
Peat	Kt						
Sub-Bituminous Coal	Kt						
Natural Gas							
Natural Gas (Dry)	Ktoe	0	0	4,649.92	0.995	4,626.67	16,964.45
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: 2014

		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)	(tC / TJ)	(t C)	(Gg C)
Manufacturing Industries and Construction							
Liquid Fuels							
Crude Oil	Kt						
Ethane	Kt						
Gas/Diesel Oil	Kt	493.45	43.33	21,381.09	20.20	431,898.02	431.90
Gasoline	Kt						
Jet Kerosene	Kt						
Liquefied Petroleum Gases (LPG)	Kt	C	C	C	C	C	C
Lubricants	Kt						
Naphtha	Kt						
Natural Gas Liquids	Kt						
Orimulsion	Kt						
Other Kerosene	Kt						
Petroleum Coke	Kt	C	C	C	C	C	C
Refinery Gas	Kt	3,485.64	48.15	167,833.54	18.20	3,054,570.50	3,054.57
Residual Fuel Oil	Kt	829.95	40.19	33,355.77	21.10	703,806.77	703.81
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	C	C	C	C	C	C
Lignite	Kt						
Other Bituminous Coal	Kt						
Patent Fuel	Kt						
Peat	Kt						
Sub-Bituminous Coal	Kt						
Natural Gas							
Natural Gas (Dry)	Ktoe	1,936.77	41.868	81,088.89	15.30	1,240,659.97	1,240.66
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: 2014

		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)
Manufacturing Industries and Construction							**20,277.21**
Liquid Fuels							
Crude Oil	Kt						
Ethane	Kt						
Gas/Diesel Oil	Kt	0	0	431.90	0.990	427.58	1,567.79
Gasoline	Kt						
Jet Kerosene	Kt						
Liquefied Petroleum Gases (LPG)	Kt	C	C	C	C	C	C
Lubricants	Kt						
Naphtha	Kt						
Natural Gas Liquids	Kt						
Orimulsion	Kt						
Other Kerosene	Kt						
Petroleum Coke	Kt	C	C	C	C	C	540.17
Refinery Gas	Kt	0	0	3,054.57	0.990	3,024.02	11,088.09
Residual Fuel Oil	Kt	0	0	703.81	0.990	696.77	2,554.82
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	C	C	C	C	C	C
Lignite	Kt						
Other Bituminous Coal	Kt						
Patent Fuel	Kt						
Peat	Kt						
Sub-Bituminous Coal	Kt						
Natural Gas							
Natural Gas (Dry)	Ktoe	0	0	1,240.66	0.995	1,234.46	4,526.34
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: 2014

		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)	(tC / TJ)	(t C)	(Gg C)
Transport							
Road Transport							
Gas/Diesel Oil	Kt	1,313.91	43.33	56,931.50	20.20	1,150,016.37	1,150.02
Gasoline	Kt	733.11	44.80	32,843.46	18.90	620,741.44	620.74
Liquefied Petroleum Gases (LPG)	Kt						
Natural Gas (Dry)	Ktoe	16.91	41.868	707.98	15.30	10,832.16	10.83
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	61.57	43.33	2,667.70	20.20	53,887.50	53.89
Gasoline	Kt						
Lubricants	Kt						
Residual Fuel Oil	Kt						
Sub-Bituminous Coal	Kt						
Domestic Aviation							
Gasoline	Kt						
Jet Kerosene	Kt						
Memo Items							
Liquid Biomass	Kt						

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

COUNTRY: SINGAPORE YEAR: 2014

		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							**6,662.98**
Road Transport							
Gas/Diesel Oil	Kt	0	0	1,150.02	0.990	1,138.52	4,174.56
Gasoline	Kt	0	0	620.74	0.990	614.53	2,253.29
Liquefied Petroleum Gases (LPG)	Kt						
Natural Gas (Dry)	Ktoe	0	0	10.83	0.995	10.78	39.52
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	0	53.89	0.990	53.35	195.61
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: 2014

		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)	(tC / TJ)	(t C)	(Gg C)
Commercial / Institutional Sector							
Liquid Fuels							
Gas/Diesel Oil	Kt						
Gasoline	Kt						
Jet Kerosene	Kt						
Liquefied Petroleum Gases (LPG)	Kt	71.55	47.31	3,384.92	17.20	58,220.63	58.22
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	876.19	3.60	3,154.27	15.20	47,944.91	47.94
Lignite	Kt						
Other Bituminous Coal	Kt						
Natural Gas							
Natural Gas (Dry)	Ktoe	17.26	41.868	722.78	15.30	11,058.54	11.06
Memo Items							
Gaseous Biomass	Kt						
Liquid Biomass	Kt						

1A4 – CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)

COUNTRY: SINGAPORE YEAR: 2014

		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							**426.61**
Liquid Fuels							
Gas/Diesel Oil	Kt						
Gasoline	Kt						
Jet Kerosene	Kt						
Liquefied Petroleum Gases (LPG)	Kt	0	0	58.22	0.990	57.64	211.34
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	0	47.94	0.995	47.71	174.92
Lignite	Kt						
Other Bituminous Coal	Kt						
Natural Gas							
Natural Gas (Dry)	Ktoe	0	0	11.06	0.995	11.00	40.35
Memo Items							
Gaseous Biomass	Kt						
Liquid Biomass	Kt						

1A4 – CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)

COUNTRY: SINGAPORE YEAR: 2014

		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)	(tC / TJ)	(t C)	(Gg C)
Residential Sector							
Liquid Fuels							
Gas/Diesel Oil	Kt						
Gasoline	Kt						
Liquefied Petroleum Gases (LPG)	Kt	23.85	47.31	1,128.31	17.20	19,406.88	19.41
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	684.61	3.60	2,464.59	15.20	37,461.80	37.46
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 and incineration of non-fossil based fraction of solid waste have been reported as a memo item in the GHG inventory. In line with the IPCC guidelines, memo items are reported but are to be excluded from the national greenhouse gas totals.
2. According to the IPCC Guidelines, autoproducers are classified under the Industry Sector.
3. IPCC default factors are used except for the Emission Factor for Gas Works Gas (15.2) which is a country-specific factor.
4. Transformation losses from the production of Gas Works Gas are included under the fuel type “Natural Gas” in the Industry Sector. Gas Works Gas was mainly produced from Natural Gas in Singapore.
5. Emissions from the combustion of Synthesis Gas are included under the fuel type “Refinery Gas” in the Industry Sector.
6. Emissions from the combustion of Liquefied Petroleum Gases (LPG) and Gas Works Gas are included under the fuel type “Petroleum Coke” in the Industry Sector.
7. ‘C’ denotes Confidential.

1A4 – CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 1)

COUNTRY: SINGAPORE YEAR: 2014

		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							**207.12**
Liquid Fuels							
Gas/Diesel Oil	Kt						
Gasoline	Kt						
Liquefied Petroleum Gases (LPG)	Kt	0	0	19.41	0.990	19.21	70.45
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	0	37.46	0.995	37.27	136.67
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: 2014

Activity			STEP 1						STEP 2					
			Fuel Consumption (TJ)						Emission Factors (kg/TJ)					
			A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
			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 Industries			9,672.10	303,916.17	1,169.43				1	1	3	30	200	30
Manufacturing Industries and Construction				80,632.77	58,844.39				10	5	2	30	200	30
Transport	Domestic Aviation[a]										0.5			
	Road				Gasoline	Diesel					Gasoline	Diesel		
				707.98						50	20	5		
	Railways								10		5			
	National Navigation[a]				2,667.70				10		5			
Other Sectors	Commercial/Institutional			722.78					10	5	10	300	200	300
	Residential								300	5	10	300	200	300
	Agriculture/ Forestry / Fishing	Stationary							300	5	10	300	200	300
		Mobile								5	5			
Other (not elsewhere specified)														
Total			**9,672.10**	**385,979.71**	**62,681.52**	**0.00**	**0.00**	**0.00**						

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: 2014

Activity			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
			C1	C2	C3		C4	C5	C6	D= sum	E	F
			Coal	Natural Gas	Oil		Wood / Wood Waste	Charcoal	Other Biomass and Wastes	(C1..C6) / 1 000 000		
Energy Industries			9,672.10	303,916.17	3,508.28					0.32	21	6.66
Manufacturing Industries and Construction				403,163.87	117,688.78					0.52	21	10.94
Transport	Domestic Aviation[a]									0.00	21	
	Road				Gasoline	Diesel				0.00	21	
				35,399.22						0.04	21	0.74
	Railways									0.00	21	
	National Navigation[a]				13,338.49					0.01	21	0.28
Other Sectors	Commercial/Institutional			3,613.90						0.00	21	0.08
	Residential									0.00	21	
	Agriculture / Forestry / Fishing	Stationary								0.00	21	
		Mobile								0.00	21	
Other (not elsewhere specified)										0.00	21	
Total			**9,672.10**	**746,093.16**	**134,535.55**		**0.00**	**0.00**	**0.00**	**0.89**	**21**	**18.70**

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

COUNTRY: SINGAPORE YEAR: 2014

Activity			STEP 1						STEP 2					
			Fuel Consumption (TJ)						Emission Factors (kg/TJ)					
			A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
			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 Industries			9,672.10	303,916.17	1,169.43				1.4	0.1	0.6	4	4	4
Manufacturing Industries and Construction				80,632.77	58,844.39				1.4	0.1	0.6	4	4	4
Transport	Domestic Aviation[a]										2			
	Road				Gasoline / Diesel						Gasoline / Diesel			
				707.98						0.1	0.6 / 0.6			
	Railways								1.4		0.6			
	National Navigation[a]				2,667.70				1.4		0.6			
Other Sectors	Commercial/Institutional			722.78					1.4	0.1	0.6	4	1	4
	Residential								1.4	0.1	0.6	4	1	4
	Agriculture/ Forestry/ Fishing	Stationary							1.4	0.1	0.6	4	1	4
		Mobile								0.1	0.6			
Other (not elsewhere specified)														
Total			**9,672.10**	**385,979.71**	**62,681.52**	**0.00**	**0.00**	**0.00**						

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: 2014

Activity			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
			C1	C2	C3	C4	C5	C6	D= sum	E	F
			Coal	Natural Gas	Oil	Wood / Wood Waste	Charcoal	Other Biomass and Wastes	(C1..C6) / 1 000 000		
Energy Industries			13,540.93	30,391.62	701.66				0.04	310	13.84
Manufacturing Industries and Construction				8,063.28	35,306.64				0.04	310	13.44
Transport	Domestic Aviation[a]								0.00	310	
	Road				Gasoline / Diesel				0.00	310	
				70.80					0.00	310	0.02
	Railways								0.00	310	
	National Navigation[a]				1,600.62				0.00	310	0.50
Other Sectors	Commercial/Institutional			72.28					0.00	310	0.02
	Residential								0.00	310	
	Agriculture/ Forestry/ Fishing	Stationary							0.00	310	
		Mobile							0.00	310	
Other (not elsewhere specified)									0.00	310	
Total			**13,540.93**	**38,597.97**	**37,608.91**	**0.00**	**0.00**	**0.00**	**0.09**	**310**	**27.82**

1A3 – NON-CO_2 FROM FUEL COMBUSTION BY SOURCE (TIER 2)

COUNTRY: SINGAPORE YEAR: 2014

Vehicle Type	Fuel Type	Vehicle Population	Emission Factor (g/ kg fuel)	Weighted-average Emission Factor	IPCC Table
Cars	Petrol	605,511	0.3	0.23863	I-36
Taxis	Petrol	543	0.3	0.00021	I-36
Tax Exempted Cars	Petrol*	2,414	0.3	0.00095	I-36
Motorcycles & Scooters+	Petrol	144,400	5.0	0.94846	I-42
Tax Exempted Motorcycles	Petrol*	622	5.0	0.00409	I-42
Buses+	Petrol	118	0.8	0.00012	I-40
Light Goods Vehicles (LGVs)	Petrol	7,625	0.8	0.00801	I-40
Sub-Total		**761,233**		**1.2005**	
Cars	Diesel	3,206	0.08	0.00129	I-37
Taxi	Diesel	24,493	0.08	0.00984	I-37
Buses-	Diesel	16,972	0.2	0.01704	I-39
Tax Exempted Buses-	Diesel*	445	0.2	0.00045	I-39
Light Goods Vehicles (LGVs)	Diesel*	87,974	0.06	0.02650	I-38
Heavy Goods Vehicles (HGVs)	Diesel*	48,908	0.2	0.04911	I-39
Tax Exempted Goods Vehicles-	Diesel*	17,191	0.2	0.01726	I-38
Sub-Total		**199,189**		**0.1215**	

Type of Fuel (Sales in Singapore)	2014 Fuel Sales (kg)	Weighted-average Emission Factor (g/ kg fuel)	CH_4 Emissions (tonnes)	CH_4 Emissions (kilotonnes-CO_2-equiv)
Petrol	733,113,000	1.2005	880.087	**18.482**
Diesel	1,313,905,000	0.1215	159.614	**3.352**

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: 2014

Vehicle Type	Fuel Type	Vehicle Population	Emission Factor (g/ kg fuel)	Weighted-average Emission Factor	IPCC Table
Cars	Petrol	605,511	0.8	0.63635	I-36
Taxis	Petrol	543	0.8	0.00057	I-36
Tax Exempted Cars	Petrol*	2,414	0.8	0.00254	I-36
Motorcycles & Scooters+	Petrol	144,400	0.06	0.01138	I-42
Tax Exempted Motorcycles	Petrol*	622	0.06	0.00005	I-42
Buses+	Petrol	118	0.06	0.00001	I-40
Light Goods Vehicles (LGVs)	Petrol	7,625	0.06	0.00060	I-40
Sub-Total		**761,233**		**0.6515**	
Cars	Diesel	3,206	0.2	0.00322	I-37
Taxi	Diesel	24,493	0.2	0.02459	I-37
Buses-	Diesel	16,972	0.1	0.00852	I-39
Tax Exempted Buses-	Diesel*	445	0.1	0.00022	I-39
Light Goods Vehicles (LGVs)	Diesel*	87,974	0.2	0.08833	I-38
Heavy Goods Vehicles (HGVs)	Diesel*	48,908	0.1	0.02455	I-39
Tax Exempted Goods Vehicles-	Diesel*	17,191	0.2	0.01726	I-38
Sub-Total		**199,189**		**0.1667**	

Type of Fuel (Sales in Singapore)	2014 Fuel Sales (kg)	Weighted-average Emission Factor (g/ kg fuel)	N_2O Emissions (tonnes)	N_2O Emissions (kilotonnes-CO_2-equiv)
Petrol	733,113,000	0.6515	477.620	**148.062**
Diesel	1,313,905,000	0.1667	219.031	**67.900**

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.

1B – FUGITIVE EMISSIONS FROM FUELS

COUNTRY: SINGAPORE YEAR: 2014

Fugitive Emissions from Fuels			
Oil and Natural Gas Systems	CO_2	Gg CO_2eq	943.576
	CH_4	Gg CO_2eq	53.957
	N_2O	Gg CO_2eq	0.866

NOTE

1. Country-specific / Site-specific factors are used where available.

2 – EMISSIONS FROM INDUSTRIAL PROCESSES AND PRODUCT USE

COUNTRY: SINGAPORE YEAR: 2014

Category	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
	Gg CO_2eq					
Mineral Industry	NO	NO	NO			
Chemical Industry	**216.858**	**C**	NO	NO	NO	NO
Metal Industry	**C**	NO	NO	NO	NO	NO
Non-Energy Products from Fuels and Solvent Use	**0.609**	NO	NO			
Electronics Industry	**C**	**C**	**44.376**	**57.351**	**1,146.830**	**146.984**
Product Uses as Substitutes for Ozone Depleting Substances	NO	NO	NO	**249.055**	**NO**	
Other Product Manufacture and Use	NO	NO	NO	NO	NO	**C**
Other	**117.199**	**77.157**	**0.572**	**NO**	**NO**	**34.975**
Total Emissions in Gg CO_2eq	**334.67**	**77.16**	**44.95**	**306.41**	**1,146.83**	**181.96**

NOTE

1. Country-specific / Site-specific factors are used where available.
2. The IPCC Tier 2 methodology is used for computing emissions from Integrated Circuit and Semiconductor Production.
3. 'C' denotes Confidential.
4. 'NO' denotes Not Occurring.

2 - EMISSIONS FROM INDUSTRIAL PROCESSES AND PRODUCT USE

COUNTRY: SINGAPORE YEAR: 2014

Breakdown of emissions for the Electronics Industry

Direct Emissions		A	B	C	D	E
				C=Ax(1-B)		E = CxDx10^{-6}
Greenhouse Gas (GHG)	Chemical Formula	Mass of F-Gases Used in Process	Fraction of F-Gas Used in Process with Emission Control Technology	Total (Direct and by-product) emissions for each GHG	Global Warming Potential	Emissions in CO_2 equivalent
		kg		kg		Gg CO_2eq
Nitrous Oxide	N_2O	C	C	143,148.35	310	44.38
HFC-23	CHF_3	C	C	4,886.23	11,700	57.17
HFC-32	CH_2F_2	C	C	279.95	650	0.18
HFC-41	CH_3F	C	C	C	150	C
PFC-14	CF_4	C	C	104,244.96	6,500	677.59
PFC-116	C_2F_6	C	C	42,128.19	9,200	387.58
PFC-218	C_3F_8	C	C	10,296.33	7,000	72.07
PFC-318	c-C_4F_8	C	C	1,101.66	8,700	9.58
Sulphur hexafluoride	SF_6	C	C	6,149.97	23,900	146.98

Breakdown of HFC emissions for Product Uses as Substitutes for Ozone Depleting Substances

Direct Emissions		A	B	C
				C = AxBx10^{-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 CO_2eq
HFC-32	CH_2F_2	1,291.66	650	0.84
HFC-125	CHF_2CF_3	2,298.95	2,800	6.44
HFC-134	CHF_2CHF_2	C	1,000	C
HFC-134a	CH_2FCF_3	31,565.67	1,300	41.04
HFC-143a	CH_3CF_3	1,138.78	3,800	4.33
HFC-227ea	CF_3CHFCF_3	C	2,900	C
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	151,089.08	1,300	196.42

NOTE

1. 'C' denotes Confidential.
2. Emissions from HFC-41 are included under HFC-32 for the Electronics Industry.
3. Emissions from HFC-134 and HFC-227ea are included under HFC-43-10mee for the category Product Uses as Substitutes for Ozone Depleting Substances.

6C - EMISSIONS FROM WASTE INCINERATION

COUNTRY: SINGAPORE YEAR: 2014

CO_2	A	B	C	D	E	F	G
							G=AxBxCxDxExF
	Total Amount of Fossil-based Waste Incinerated (Wet Weight)	Fraction of 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
	1,880.30	C	C	C	1	3.6667	1,570.765

CH_4	A	B	C	D	E
			C=AxBx10^{-9}		E=CxD
	Total Amount of Waste Incinerated (Wet Weight)	CH_4 Emission Factor	CH_4 Emissions	Global Warming Potential of CH_4	Emissions in CO_2eq
	tonnes	kg CH_4/kt waste	Gg		Gg
	2,872,396.42	0.2	0.001	21	0.012

N_2O	A	B	C	D	E
			C=AxBx10^{-9}		E=CxD
	Total Amount of Waste Incinerated (Wet Weight)	N_2O Emission Factor	N_2O Emissions	Global Warming Potential of N_2O	Emissions in CO_2eq
	tonnes	kg N_2O/kt waste	Gg		Gg
	2,872,396.42	47	0.135	310	41.851

NOTE

1. The CO_2, CH_4 and N_2O emissions are added to the total emissions from fuel combustion (All Energy - Fuel combustion - Energy and Transformation Industries).
2. The CH_4 and N_2O emissions are reflected in CO_2eq in the GHG summary table (All Energy - Fuel combustion - Energy and Transformation Industries).
3. 'C' denotes Confidential.
4. Default conversion and emission factors from the 2006 IPCC Guidelines are used for estimating emissions from waste incineration.

6C – EMISSIONS FROM HAZARDOUS WASTE INCINERATION

COUNTRY: SINGAPORE YEAR: 2014

	A	B	C	D	E	F
						F=AxBxCxDxE
CO_2	Total Amount of Hazardous Waste Incinerated (Wet Weight)	Fraction of Carbon in Dry Matter (total carbon content)	Fraction of Fossil Carbon In The Total Carbon	Oxidation Factor	Conversion Factor	CO_2 Emissions
	kt	fraction	fraction	fraction	44/12	Gg
	117.95	0.5	0.9	1	3.6667	194.616

	A	B	C	D	E
			$C=AxBx10^{-6}$		E=CxD
CH_4	Total Amount of Hazardous Waste Incinerated (Wet Weight)	CH_4 Emission Factor	CH_4 Emissions	Global Warming Potential of CH_4	Emissions in CO_2eq
	kt	kg CH_4/kt waste	Gg		Gg
	117.95	0.2	0.000024	21	0.000495

	A	B	C	D	E
			$C=AxBx10^{-6}$		E=CxD
N_2O	Total Amount of Hazardous Waste Incinerated (Wet Weight)	N_2O Emission Factor	N_2O Emissions	Global Warming Potential of N_2O	Emissions in CO_2eq
	kt	kg N_2O/kt waste	Gg		Gg
	117.95	50	0.0059	310	1.828

NOTE

1. The CH_4 and N_2O emissions are reflected in CO_2eq in the GHG summary table (Waste - Hazardous Waste Incineration).

6C – EMISSIONS FROM CLINICAL WASTE INCINERATION

COUNTRY: SINGAPORE YEAR: 2014

	A	B	C	D	E	F	G
							G=AxBxCxDxExF
CO_2	Total Amount of Clinical Waste Incinerated (Wet Weight)	Fraction of Dry Matter Content in Waste (Wet Weight) Incinerated	Fraction of Carbon in Dry Matter (Total Carbon Content)	Fraction of Fossil Carbon in the Total Carbon	Oxidation Factor	Conversion Factor	CO_2 Emissions
	kt	fraction	fraction	fraction	fraction	44/12	Gg
	3.34	0.65	0.6	0.4	1	3.6667	1.909

	A	B	C	D	E
			$C=AxBx10^{-6}$		E=CxD
CH_4	Total Amount of Clinical Waste Incinerated (Wet Weight)	CH_4 Emission Factor	CH_4 Emissions	Global Warming Potential of CH_4	Emissions in CO_2eq
	kt	kg CH_4/kt waste	Gg		Gg
	3.34	0.2	0.000001	21	0.000014

	A	B	C	D	E
			$C=AxBx10^{-6}$		E=CxD
N_2O	Total Amount of Clinical Waste Incinerated (Wet Weight)	N_2O Emission Factor	N_2O Emissions	Global Warming Potential of N_2O	Emissions in CO_2eq
	kt	kg N_2O/kt waste	Gg		Gg
	3.34	50	0.0002	310	0.052

NOTE

1. The CH_4 and N_2O emissions are reflected in CO_2eq in the GHG summary table (Waste - Clinical Waste Incineration).

6B – EMISSIONS FROM WASTEWATER HANDLING

COUNTRY: SINGAPORE YEAR: 2014

		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
	61.00	22.265	5,469,724	0.16	0.01	0.306	310	94.921

NOTE

1. The annual per capita protein intake is the average of the UNFAO data for ASEAN member states.
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: 2014

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	DOC_f	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	27.880

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: 2014

Incineration of sludge		
CH_4	Gg CO_2eq	0.061
N_2O	Gg CO_2eq	16.263

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 incineration of sludge are computed based on CDM methodologies.

EMISSIONS AND REMOVALS OF CO_2 AND NON-CO_2 GASES FROM AFOLU* (SECTORAL TABLE 1 OF 2)

COUNTRY: SINGAPORE YEAR: 2014

Categories	Net CO_2 emissions/ removals	Emissions				
	CO_2	CH_4	N_2O	NOx	CO	NMVOC
	(Gg)					
3 AFOLU*	53.64	NO/NE	0.03	NA	NA	NA
3A Livestock*		NE	NE			
3A1 Enteric Fermentation		NE				
3A1a Cattle		NO				
3A1ai Dairy Cows		NE				
3A1aii Other Cattle		NO				
3A1b Buffalo		NO				
3A1c Sheep		NO				
3A1d Goats		NE				
3A1e Camels		NO				
3A1f Horses		NO				
3A1g Mules and Asses		NO				
3A1h Swine		NO				
3A1j Other (please specify)		NO				
3A2 Manure Management (1)		NE	NE			
3A2a Cattle		NO	NO			
3A2ai Dairy Cows		NE	NE			
3A2aii Other Cattle		NO	NO			
3A2b Buffalo		NO	NO			
3A2c Sheep		NO	NO			
3A2d Goats		NE	NE			
3A2e Camels		NO	NO			
3A2f Horses		NO	NO			
3A2g Mules and Asses		NO	NO			
3A2h Swine		NO	NO			
3A2i Poultry		NE	NE			
3A2j Other (please specify)		NO	NO			
3B Land (2)	53.64					

EMISSIONS AND REMOVALS OF CO_2 AND NON-CO_2 GASES FROM AFOLU* (SECTORAL TABLE 1 OF 2)

COUNTRY: SINGAPORE YEAR: 2014

Categories	Net CO_2 emissions/ removals	Emissions				
	CO_2	CH_4	N_2O	NOx	CO	NMVOC
	(Gg)					
3B1 Forest Land	-58.34					
3B1a Forest Land Remaining Forest Land	-36.17					
3B1b Land Converted to Forest Land	-22.17					
3B1bi Cropland Converted to Forest Land	-0.23					
3B1bii Grassland Converted to Forest Land	NO					
3B1biii Wetlands Converted to Forest Land	-1.16					
3B1biv Settlements Converted to Forest Land	-19.42					
3B1bv Other Land Converted to Forest Land	NO					
3B1bvi Other (Sea) converted to Forest Land	-1.37					
3B2 Cropland	3.09					
3B2a Cropland Remaining Cropland	2.47					
3B2b Land Converted to Cropland	0.62					
3B2bi Forest Land Converted to Cropland	1.02					
3B2bii Grassland Converted to Cropland	NO					
3B2biii Wetlands Converted to Cropland	-0.02					
3B2biv Settlements Converted to Cropland	-0.39					
3B2bv Other Land Converted to Cropland	NO					
3B2bvi Other (Sea) converted to Cropland	0.00					
3B3 Grassland	NO					
3B3a Grassland Remaining Grassland	NO					
3B3b Land Converted to Grassland	NO					
3B3bi Forest Land Converted to Grassland	NO					
3B3bii Cropland Converted to Grassland	NO					
3B3biii Wetlands Converted to Grassland	NO					
3B3biv Settlements Converted to Grassland	NO					
3B3bv Other Land Converted to Grassland	NO					
3B3bvi Other (Sea) converted to Grassland	NO					

EMISSIONS AND REMOVALS OF CO_2 AND NON-CO_2 GASES FROM AFOLU* (SECTORAL TABLE 2 OF 2)

COUNTRY: SINGAPORE YEAR: 2014

Categories	Net CO_2 emissions/ removals	Emissions				
	CO_2	CH_4	N_2O	NOx	CO	NMVOC
	(Gg)					
3B4 Wetlands	2.73					
3B4a Wetlands Remaining Wetlands	NO					
3B4ai Peat Extraction Remaining Peat Extraction	NO					
3B4aii Flooded Land Remaining Flooded Land	NO					
3B4aiii Other Wetlands Remaining Other Wetlands	NO					
3B4b Land Converted to Wetlands	2.73					
3B4bi Land Converted for Peat Extraction	NO					
3B4bii Land Converted to Flooded Land	2.73					
3B4biii Land Converted to Other Wetlands	NO					
3B5 Settlements	106.16					
3B5a Settlements Remaining Settlements	-29.01					
3B5b Land Converted to Settlements	135.17					
3B5bi Forest Land Converted to Settlements	151.24					
3B5bii Cropland Converted to Settlements	1.74					
3B5biii Grassland Converted to Settlements	NO					
3B5biv Wetlands Converted to Settlements	-2.51					
3B5bv Other Land Converted to Settlements	NO					
3B5bvi Other (Sea) converted to Settlements	-15.31					
3B6 Other Land	NO					
3B6a Other Land Remaining Other Land	NO					
3B6b Land Converted to Other Land	NO					
3B6bi Forest Land Converted to Other Land	NO					
3B6bii Cropland Converted to Other Land	NO					
3B6biii Grassland Converted to Other Land	NO					
3B6biv Wetlands Converted to Other Land	NO					
3B6bv Settlements Converted to Other Land	NO					
3C Aggregate Sources and Non-CO_2 Emissions Sources on Land (3)	NO	NO	0.03			
3C1 Burning	NO	NO	NO			

EMISSIONS AND REMOVALS OF CO_2 AND NON-CO_2 GASES FROM AFOLU* (SECTORAL TABLE 2 OF 2)

COUNTRY: SINGAPORE YEAR: 2014

Categories	Net CO_2 emissions/ removals	Emissions				
	CO_2	CH_4	N_2O	NOx	CO	NMVOC
	(Gg)					
3C1a Burning in Forest Land	NO	NO	NO			
3C1b Burning in Cropland	NO	NO	NO			
3C1c Burnings in Grassland	NO	NO	NO			
3C1d Burnings in All Other Land	NO	NO	NO			
3C2 Liming	NO					
3C3 Urea Fertilization	NE					
3C4 Direct N_2O Emissions from Managed Soils (4)			0.02			
3C5 Indirect N_2O Emissions from Managed Soils			0.00			
3C6 Indirect N_2O Emissions from Manure Management			NE			
3C7 Rice Cultivations		NO				
3C8 CH_4 from Drained Organic Soils		NO				
3C9 CH_4 from Drainage Ditches on Organic Soils		NO				
3C10 CH_4 from Rewetting of Organic Soils		NO				
3C11 CH_4 Emissions from Rewetting of Mangroves and Tidal Marshes		NO				
3C12 N_2O Emissions from Aquaculture			NE			
3C13 CH_4 Emissions from Rewetted and Created Wetlands on Inland Wetland Mineral Soils		NO				
3C14 Other (please specify)	NO	NO	NO			
3D Other	0.01	NO	NO			
3D1 Harvested Wood Products	NO					
3D2 Other (Sea)	0.01	NO	NO			

(1) Indirect N_2O emissions are not included here (see category 3C6).
(2) Net CO_2 emissions/removals from land may include emissions from coastal wetlands that are not part of the total land area of the reporting country.
(3) If CO_2 emissions from Biomass Burning are not already included in Table 3.2 (Carbon stock changes background table), they should be reported here.
(4) Countries may report by land categories if they have the information.
* Cells to report emissions of NO_x, CO, and NMVOC have not been shaded although the physical potential for emissions is lacking for some categories.

Documentation box:

*Important note: Information on emissions from Agriculture is not estimated or not occurring.

GREENHOUSE GAS SUMMARY TABLE FOR 2012

COUNTRY: SINGAPORE YEAR: 2012

AS REPORTED IN SINGAPORE'S SECOND BIENNIAL REPORT

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)	47,013.71	86.74	409.12	37.92	930.83	89.33
All Energy	**46,869.97**	**41.21**	**307.05**			
Fuel Combustion	**46,644.45**	**41.21**	**307.05**			
Energy and transformation industries	20,458.59	9.03	73.03			
Industry	18,599.61	8.63	14.46			
Transport	6,946.38	23.49	219.54			
Commercial-institutional	431.25	0.05	0.02			
Residential	208.61					
Fugitive fuel emission	**225.52**					
Oil and natural gas systems	255.52					
Industrial Processes				**37.92**	**930.83**	**89.33**
Land Use, Land-Use Change and Forestry	**-41.01**	**NO**	**8.12**			
Waste	**184.75**	**45.53**	**93.95**			
Wastewater handling		45.53	92.19			
Hazardous waste incineration	183.27	~0.00	1.72			
Clinical waste incineration	1.49	~0.00	0.04			

NOTE

1. In line with IPCC Good Practice Guidance to continually review the GHG inventory, the figures have been updated where necessary.
2. The greenhouse gas emissions from Agriculture and Land Use, 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 2010

COUNTRY: SINGAPORE YEAR: 2010

AS REPORTED IN SINGAPORE'S THIRD NATIONAL COMMUNICATION AND FIRST BIENNIAL REPORT

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)	45,432.84	113.92	401.62	39.94	987.91	86.25
All Energy	**45,242.48**	**42.71**	**304.94**			
Fuel Combustion	**45,086.63**	**42.71**	**304.94**			
Energy and transformation industries	20,746.29	10.11	77.17			
Industry	16,963.89	8.10	14.14			
Transport	6,722.15	24.45	213.62			
Commercial-institutional	455.20	0.06	0.02			
Residential	209.10					
Fugitive fuel emission	**155.84**					
Oil and natural gas systems	155.84					
Industrial Processes				**39.94**	**987.91**	**86.25**
Land Use, Land-Use Change and Forestry	**-16.45**	**NO**	**7.89**			
Waste	**206.82**	**71.21**	**88.78**			
Wastewater handling		71.21	86.82			
Hazardous waste incineration	205.46	~0.00	1.93			
Clinical waste incineration	1.36	~0.00	0.04			

NOTE

1. In line with IPCC Good Practice Guidance to continually review the GHG inventory, the figures have been updated where necessary.
2. The greenhouse gas emissions from Agriculture and Land Use, 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 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)	37,273.79	156.27	341.41	7.47	466.59	84.04
All Energy	**37,079.39**	**34.97**	**255.49**			
Fuel Combustion	**37,079.39**					
Energy and transformation industries	20,297.33	15.28	66.23			
Industry	10,526.41					
Transport	5,621.58	19.68	189.26			
Commercial-institutional	291.62					
Residential	342.45					
Fugitive fuel emission	**132.91**					
Oil and natural gas systems	132.91					
Industrial Processes				**7.47**	**466.59**	**84.04**
Land Use, Land-Use Change and Forestry	**61.49**	**NO**	**12.17**			
Waste		**121.30**	**73.75**			
Wastewater handling		121.30	73.75			

NOTE

1. In line with IPCC Good Practice Guidance to continually review the GHG inventory, the figures have been updated where necessary.
2. The CH_4 and N_2O emissions under the Energy and transformation industries sector includes the CH_4 and N_2O emissions from industry, transport (CNG), commercial-institutional and residential sub-sectors.
3. The greenhouse gas emissions from Agriculture and Land Use, 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 and Land Use, Land-Use Change and Forestry sectors are negligible in comparison with the size of carbon stocks and in comparison with other economic sectors.

GLOSSARY

GLOSSARY

3P	People, Private and Public
AAP	AWGCC Action Plan
AMS	ASEAN Member States
APEC	Asia-Pacific Economic Cooperation
AR5	Fifth Assessment Report
ASEAN	Association of Southeast Asian Nations
ATM	Air Traffic Management
AVA	Agri-Food and Veterinary Authority
AWGCC	ASEAN Working Group on Climate Change
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
BUR	Biennial Update Report
C40	C40 Cities Climate Leadership Group
CA	Climate Analytics
CAAS	Civil Aviation Authority of Singapore
CAGR	Compounded Annual Growth Rate
CAP	Climate Action Package
CAS	Coastal Adaptation Study
CCGT	Combined Cycle Gas Turbine
CCRS	Centre for Climate Research Singapore
CCSU	Carbon Capture, Storage and Utilisation
CDL	City Developments Limited
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CERT	Clean Energy Research Testbedding
CEVS	Carbon Emissions-based Vehicle Scheme
CH_4	Methane
CLT	Cross Laminated Timber
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CO_2eq	Carbon Dioxide Equivalent
CO	Carbon Monoxide
COP-21	21st Conference of the Parties to the United Nations Framework Convention on Climate Change
CSB	Centre for Sustainable Buildings
DC	Data Centre
DOC	Degradable Organic Carbon
DTSS	Deep Tunnel Sewerage System
E2F	Energy Efficiency Fund
EASe	Energy Efficiency Improvement Assistance Scheme
ECA	Energy Conservation Act
EDB	Economic Development Board
EDMA	Emissions Data Monitoring and Analysis
EHI	Environmental Health Institute
EMA	Energy Market Authority
EPHA	Environmental Public Health Act
Exco	Executive Committee
EPMA	Environmental Protection and Management Act
FAO	Food and Agriculture Organisation
FELS	Fuel Economy Labelling Scheme
Gg	Gigagram
GHG	Greenhouse Gas
GM	Green Mark
GMGFA	Green Mark Gross Floor Area
GMIS-EBP	Green Mark Incentive Scheme for Existing Buildings and Premises
GREET	Grant for Energy Efficient Technologies
GTP	Green Technology Programme
GWh	Gigawatt-Hour
GWP	Global Warming Potential
HDB	Housing and Development Board
HFCs	Hydrofluorocarbons
HGVs	Heavy Goods Vehicles
HUJ	Hebrew University of Jerusalem
ICA	International Consultations and Analysis
ICAO	International Civil Aviation Organisation
ICI	International Climate Initiative
ICT	Information and Communications Technology
IEA	International Energy Agency
IMCCC	Inter-Ministerial Committee on Climate Change
IMDA	Info-communications Media Development Authority
IMO	International Maritime Organisation
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IWMF	Integrated Waste Management Facility
JSPP21	Japan-Singapore Partnership Programme for the 21st Century
KCA	Key Category Analysis
kg	Kilogram
kt	Kilo-Tonnes
LDCs	Least Developed Countries
LGVs	Light Goods Vehicles
LNG	Liquefied Natural Gas
LPAA	Lima Paris Action Agenda

GLOSSARY

LPG	Liquefied Petroleum Gas
LTA	Land Transport Authority
LULUCF	Land Use, Land-Use Change and Forestry
LWG	Long Term Emissions and Mitigation Working Group
MCF	Methane Correction Factor
MELS	Mandatory Energy Labelling Scheme
MEPS	Minimum Energy Performance Standards
MEWR	Ministry of the Environment and Water Resources
MGO/MDO	Marine Gas Oil/Marine Diesel Oil
MIT	Massachusetts Institute of Technology
MLIT	Japan Ministry of Land, Infrastructure, Transport and Tourism
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
MSGI	Maritime Singapore Green Initiative
MSS	Meteorological Service Singapore
Mt	Million Tonnes
MWp	Mega-Watt Peak
N_2O	Nitrous Oxide
NAMAs	Nationally Appropriate Mitigation Actions
NC	National Communication
NCCS	National Climate Change Secretariat
NDC	Nationally Determined Contribution
NEA	National Environment Agency
NGOs	Non-Governmental Organisations
NMVOCs	Non-Methane Volatile Organic Compounds
NOx	Nitrogen oxides
NParks	National Parks Board
NRF	National Research Foundation
NTU	Nanyang Technological University
NUS	National University of Singapore
OPC	Off-Peak Car
PFCs	Perfluorocarbons
PUB	PUB, Singapore's National Water Agency
PUE	Power Usage Effectiveness
PV	Photovoltaic
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
RAC	Refrigeration and Air-Conditioning
RWG	Resilience Working Group
SAMCA	Special ASEAN Ministerial Meeting on Climate Action
SCP	Singapore Cooperation Programme
SCS	Solar Capability Scheme
SDCC	Sustainable Development and Climate Change
SE4All	Working Session of the Sustainable Energy for All
SEAS	Sustainable Energy Association of Singapore
SF_6	Sulphur Hexafluoride
SIDS	Small Island Developing States
SJTU	Shanghai Jiao Tong University
SLA	Singapore Land Authority
SO_2	Sulphur Dioxide
SWDS	Solid Waste Disposal Site
tCO_2e	tonne of CO_2-equivalent
TUM	Technical University of Munich
TWRP	Tuas Water Reclamation Plan
UCB	University of California, Berkeley
UFW	Unaccounted-for-Water
UIUC	University of Illinois at Urbana-Champaign
UNFCCC	United Nations Framework Convention on Climate Change
URA	Urban Redevelopment Authority
VES	Vehicular Emissions Scheme
WEF	World Economic Forum
WRI	World Resources Institute

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