Climate Change & Singapore:

Challenges. Opportunities. Partnerships.

NATIONAL CLIMATE CHANGE STRATEGY 2012

Creating a climate for sustainable growth,
Securing a liveable environment for our future

Cover image:
Clear skies, viewed from the Marina Barrage Green Roof.

Climate Change & Singapore:

Challenges. Opportunities. Partnerships.

NATIONAL CLIMATE CHANGE STRATEGY 2012

Creating a climate for sustainable growth,
Securing a liveable environment for our future

NATIONAL CLIMATE CHANGE STRATEGY 2012

PUBLISHED BY:
National Climate Change Secretariat
Prime Minister's Office
Republic of Singapore
www.nccs.gov.sg

IN COLLABORATION WITH:
Ministry of Finance
Ministry of Foreign Affairs
Ministry of National Development
Ministry of the Environment and Water Resources
Ministry of Trade and Industry
Ministry of Transport
Agency for Science, Technology and Research
Building and Construction Authority
Civil Aviation Authority of Singapore
Economic Development Board
Energy Market Authority
Housing & Development Board
International Enterprise Singapore
JTC Corporation
Land Transport Authority
Maritime and Port Authority of Singapore
Nanyang Technological University
National Environment Agency
National Parks Board
National Research Foundation
National University of Singapore
PUB, Singapore's National Water Agency
Urban Redevelopment Authority

With thanks to all contributors to the NCCS-2012 e-consultation exercise for their feedback and suggestions, those who participated in the focus group discussion and public forums, and the Community Development Councils for their assistance in organising the public forums.

ISBN: 978-981-07-2492-4

Design and Production by Silicon+

CONTENTS

FOREWORD

The Climate Change Imperative

Climate change affects us all, including Singapore...

The global climate is changing. Average global temperature and sea levels are expected to rise if carbon emissions from human activities continue to grow unchecked, and extreme weather events are likely to become more intense and frequent.

What does this mean for Singapore? Extreme weather events can lead to changes in rainfall patterns, resulting in more intense rainfall or drier periods. Flood and water management will be of even greater importance for Singapore. In addition, more frequent extreme weather events may lead to volatile global food prices and disruptions to business supply chains. This will affect business activities in Singapore and our food imports.

Countries are working on a global solution...

To minimise the impact from climate change, efforts from both developed and developing countries are underway to reduce emissions. At the United Nations Climate Change Conference in Durban in 2011, all countries agreed to start negotiations on a new climate change framework beyond 2020. As a responsible global citizen, Singapore will do our part to reduce emissions, while ensuring that we continue to grow and prosper.

Singapore will do our part...

The Inter-Ministerial Committee on Climate Change (IMCCC) will study how Singapore can stabilise our long-term emissions. Its work will build on Singapore's past and ongoing efforts in sustainable development. The clean and green living environment we enjoy today is the result of the high priority we have placed on protecting the environment over the years. For instance, we generate about 80% of our electricity from natural gas—the cleanest form of fossil fuel.

Efforts to reduce our long-term emissions will be challenging. Our small size limits our ability to draw on alternative energy such as solar, wind or nuclear. Nonetheless, we will enhance energy efficiency efforts and develop low carbon technologies to overcome current constraints.

Preparing Singapore for climate change...

Apart from reducing emissions, we need to adapt to the impact of climate change. We will invest in new capabilities in climate science to achieve a deeper understanding of our vulnerabilities, and develop appropriate adaptation solutions to protect Singapore against the risks posed by climate change.

At the same time, Singapore is well positioned to tap the economic opportunities arising from climate change. We can create high-value jobs for Singaporeans and enable our economy to benefit from green growth, if we continue to strengthen our R&D capabilities and attract investments to upgrade existing industries and in new growth areas.

The IMCCC will drive Singapore's efforts to realise our vision of a climate resilient global city poised for green growth. Singapore's plans to prepare for climate change are laid out in this National Climate Change Strategy 2012 document. Its title, "Climate Change & Singapore: Challenges. Opportunities. Partnerships." reflects the key elements of our efforts—preparing Singapore for the uncertainties and impact of climate change, seizing opportunities and supporting Singapore's transition to a lower emission economy.

A home that is flourishing and enduring...

To achieve our goal of a home that is flourishing and enduring, the people, private and public sectors need to work in close partnership. The Government will play its part by setting the policy framework, putting in place appropriate incentives, facilitating capability development efforts, and easing the transition. The implementation of policies will be paced so that our economy and our people can adapt to the new circumstances.

Everyone has a part to play whether through lifestyle adjustments or changes to business processes. Making adjustments earlier will make the transition easier. Every individual effort, such as buying more energy efficient appliances, taking public transport, and using less energy, will count.

To rise to the challenge, we need to be pragmatic and practical, yet bold and visionary. Let us work together to ensure that Singapore remains a flourishing and enduring city which current and future generations of Singaporeans are proud to call home.

TEO CHEE HEAN

Deputy Prime Minister

Chairman of the Inter-Ministerial Committee on Climate Change

Coordinating Minister for National Security and Minister for Home Affairs

OVERVIEW

Global Mission, National Vision, Local Action

What is climate change, and why does it matter?

What does it mean for Singapore, now and in the future?

What have we been doing about it, and what can be done going forward?

This National Climate Change Strategy document seeks to address these vital questions. It outlines current thinking about climate change and its implications for Singapore. It also highlights the initiatives and strategies we are pursuing to prepare for the challenges that climate change poses.

Impact of Climate Change

Scientists and experts around the world have yet to fully agree on how quickly climate-related changes will occur, or how severe their consequences will be. However, significant changes are already taking place. Calamities related to extreme weather events have become much more frequent worldwide.

According to the United Nations' Intergovernmental Panel on Climate Change (IPCC), if greenhouse gas emissions from human activities continue to grow unchecked, climate change is projected to accelerate, with potentially significant impact on water, ecosystems, food, coastal zones and human health.

There are low-lying areas with thousands of islands and coastal cities in Southeast Asia, and Singapore is one of them. Our neighbouring countries have already experienced increasingly intense storms and tropical cyclones, flooding and prolonged droughts in recent years. Rises in sea level and ambient temperature have already been observed for Singapore. The possible effects of changing weather patterns on Singapore include accelerated coastal erosion and higher incidences of intense rain or prolonged drought. Climate change will also affect the biodiversity of plants and animals, and our greenery. Singapore may also experience disruptions to food supplies and business supply chains if our trading partners are affected by extreme weather events.

The world does not have the luxury of time for debate on the causes of climate change to be completely settled before taking any action. We have to rely on the best prevailing scientific consensus to prepare for the risks and challenges of an uncertain future.

A Global Approach is Essential

As a small low-lying city-state with an open economy, Singapore is particularly vulnerable to the consequences of climate change. Accordingly, we have a deep interest in global efforts to address potential disruptions to natural ecosystems and human societies.

No single country can hope to address climate change on its own. In our highly interdependent world, nations big and small, developed and developing, will need to work closely together to tackle this global challenge.

Singapore has always been a strong supporter of multilateral approaches to global issues. **A system in which all countries are guided by common rules will provide assurance that each country is doing its part.** This is far preferable to a situation where countries adopt unilateral, uncoordinated and even conflicting measures that could distort trade flows and development, and lead to suboptimal outcomes at the global level. These considerations are particularly important for trade-dependent countries like Singapore.

Ultimately, a global approach that successfully reduces the harmful effects of climate change will also provide more conducive conditions for Singapore's long-term growth and development. This is why Singapore supports the multilateral negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, as well as other key UN specialised agencies such as the International Maritime Organisation (IMO) and the International Civil Aviation Organisation (ICAO).

Principles for an Effective Global Agreement

International negotiations will take time. Each country has different national circumstances and vulnerabilities which will have to be adequately addressed for any global agreement to be acceptable to all countries.

The UN-led negotiations on climate change are based on the principle of "common but differentiated responsibilities and respective capabilities". Developed countries, whose past industrialisation activities generated the bulk of historical emissions contributing to current climate change, must take the lead to reduce emissions. Developing countries, on their part, have to strive towards minimising the growth rate of their emissions whilst seeking to reduce poverty and pursue development, and reducing their emissions when they can. All countries will need to work together to protect our common environment while forging sustainable new growth paths for the global economy.

Collective efforts to control emissions should take into account our highly diverse and connected global economy, and the international division of labour. Some countries specialise in producing goods, while others are services-oriented. Countries that specialise in manufacturing activities will usually have higher carbon emissions to begin with, and it will be important for such maufacturing bases to work together to improve energy and carbon efficiencies. It will be counterproductive, for instance, if efforts to reduce emissions result in the relocation of these activities to other sites or countries that are less efficient, thus generating more carbon emissions globally.

Measures to reduce emissions will need to be consistent with international law and established principles, such as global trade rules. This will give businesses regulatory certainty, and provide a conducive environment for investment and research on climate-friendly goods and services.

Besides addressing the emissions due to fuel combustion occurring within national boundaries, an effective global climate change agreement must also address emissions that are trans-boundary in nature, such as those due to international aviation and maritime transport, and promote efforts to maintain existing carbon sinks that store carbon, such as the world's forests. For international transport emissions, the ICAO and IMO have implemented and continue to develop global measures to address emissions from international aviation and maritime transport respectively. It is important that the ICAO and IMO, with their specialist expertise and global regulatory framework, continue to lead in addressing emissions from these sectors. The world's forests serve as reservoirs of stored carbon. Emissions occur when deforestation or forest degradation takes place. This contributes up to 12% of global greenhouse gas emissions.[1] As such, the global community accepts the need for effective implementation of REDD+ (Reducing Emissions from Deforestation and Degradation Plus[2]). REDD+ efforts could also help to reduce incidences of forest fires and the consequent haze, lessen changes in regional weather patterns and climate, and reduce the impact of deforestation on biodiversity and displacement of local communities.

[1] Source: Climate Analysis Indicators Tool (CAIT), World Resources Institute. 2005 data, greenhouse gases (CO_2, CH_4, N_2O, PFCs, HFCs, SF_6) included.

[2] REDD+ (reducing emissions from deforestation and forest degradation, conservation of forest carbon stocks, sustainable management of forests and enhancement of forest carbon stocks) is based on the principle that developing countries, which are willing and able to reduce emissions from deforestation and forest degradation via the sustainable management of forests, conservation of existing carbon stocks and enhancement of carbon stocks should be financially compensated by developed countries for doing so. Emissions reductions from such activities can be quantified, and subject to agreement, they might be used by developed countries to offset their emissions from domestic sectors.

Prime Minister Lee Hsien Loong articulated Singapore's position on a future climate agreement at the start of the UNFCCC negotiations in Bali in 2007—**the need for all countries to act, the importance of economic growth to provide resources to address climate change, and for each country's contribution to take account of its national circumstances.** Singapore has consistently advocated these principles.

Successive Chairpersons of the Inter-Ministerial Committee on Climate Change—then-Senior Minister S Jayakumar and Deputy Prime Minister Teo Chee Hean—have highlighted the need for a balanced and legally binding global agreement between all countries, underpinned by common, transparent rules, to engender confidence in the multilateral process.

Prime Minister Lee Hsien Loong at the UNFCCC Conference in Bali on 12 December 2007. He explained the need for all countries to act, the importance of economic growth, and the need to consider differences in national circumstances.

Preparing for Climate Change: Our Economy and Environment

Even as negotiations for a climate change agreement for the post-2020 period are ongoing, it is important for Singapore to make preparations now for this uncertain and challenging future. Countries that plan ahead will be better able to respond—both in terms of domestic measures to protect our immediate environment and reduce emissions, and also by collaborating with others to find workable and scalable solutions. Singapore will continue to support the multilateral negotiations under the auspices of the UNFCCC and other UN specialised agencies, and other global efforts to address climate change. Singapore-based companies and institutes can also create new opportunities for a low carbon future, by proactively developing innovative technologies and solutions today.

Singapore has always placed a high priority on environmental issues as part of its aim to create a clean and green garden city for its people. Since independence in 1965, long before climate change became a global issue, Singapore has pursued concurrent goals of growing the economy and protecting the environment. In 1970, the Anti-Pollution Unit was established under the Prime Minister's Office to tackle air pollution. As early as 1972, following the UN Conference on the Human Environment in Stockholm,[3] Singapore set up a dedicated Ministry of the Environment. Singapore also participated actively in the 1992 United Nations Conference on Environment and Development (UNCED[4]) (commonly known as the Rio or Earth Summit) which adopted the UNFCCC. The preparatory committee of UNCED and the Main Committee of the Rio meeting was chaired by Singapore's Ambassador-at-Large Tommy Koh. The first Singapore Green Plan was issued thereafter, highlighting Singapore's commitment to ensure our environmental sustainability.[5] In 2009, the Sustainable Singapore Blueprint which outlined our sustainable development targets till 2030 was published.

Ambassador-at-Large Tommy Koh chairing the Preparatory Committee of UNCED in 1992. Singapore participated actively in the Conference which later led to the formation of UNFCCC.

[3] The Stockholm Conference is widely regarded as the first international forum on global environmental challenges.

[4] The United Nations Conference on Environment and Development, also known as the Earth Summit, was held in Rio de Janeiro.

[5] The Green Plan was updated in 2002 and 2006.

While Singapore's early initiatives to protect the environment have laid a strong foundation for policy action, our reputation as a clean and green garden city is also the outcome of decades of sustained effort and conscious decisions. For instance, fuel oil was replaced by natural gas—the cleanest form of fossil fuel—as the primary fuel for electricity generation. About 80% of Singapore's electricity is now generated by natural gas. Singapore is also the only country in the world to cap vehicle growth and price vehicle usage aggressively. However, these and other earlier initiatives limit our scope to further reduce emissions growth, because many of the gains have already been reaped. As a country, Singapore generates relatively low levels of CO_2 emissions per GDP dollar in the world (123rd out of 137 countries).[6]

Nonetheless, the Singapore Government remains committed to reduce emissions growth further. Plans to improve energy efficiency in all sectors of the economy were included in its 2009 Sustainable Singapore Blueprint. Prior to the 2009 Copenhagen Climate Change Conference, Singapore pledged to reduce our emissions by 16% from the 2020 business-as-usual (BAU) level, contingent on a legally binding global agreement in which all countries implement their commitments in good faith. Although a legally binding agreement has yet to be reached, Singapore has nonetheless started to implement mitigation and energy efficiency measures which should reduce our emissions by 7% to 11% from the 2020 BAU level. This pledge is not contingent on international financing and Singapore will utilise our domestic resources. The first phase of measures to encourage even greater public transport usage and improve energy efficiency in industry, buildings and households is being rolled out.

To achieve more emissions reductions over time will require deeper behavioural adjustments and changes in business processes. There is a need to consider more stringent energy efficiency standards and legislation, more innovative energy efficiency financing schemes and capability development initiatives. Market forces will also have an important role to play to ensure that people and businesses get the right carbon price signal and have the right incentives to reduce carbon emissions. Where these measures result in additional upfront costs, we will be prepared to help those that need it.

Despite our best efforts to reduce emissions, Singapore is constrained as a small and highly urbanised city-state, with more than 5 million people occupying a land area of about 710km^2. There is no rural hinterland and limited access to alternative, low-emission energy sources such as wind, hydro, biomass, geothermal or nuclear power. Deployment of solar power is limited by Singapore's small land area. Singapore, as an alternative-energy disadvantaged city-state, relies on imported fuels to power our daily activities, and there are no viable technology alternatives that can replace our reliance on fossil fuels in the foreseeable future. Given these physical constraints, our total emissions are projected to grow in the near term but we will reduce our emissions below BAU levels.

With concerted research and development efforts over time, emerging technologies could gradually enhance our ability to reduce emissions. Singapore can share this know-how with other countries which have greater potential for deployment. As a small city-state with significant expertise in sustainable urban solutions, Singapore is doing our utmost to raise energy efficiency levels, support companies and businesses to test new technologies, business models and solutions, so that climate-friendly goods and services can be developed, improved, and eventually exported.

[6] Source: CO_2 Emissions from Fuel Combustion—2011 Highlights © OECD/International Energy Agency, 2011.

Our constraints and unique circumstances mean that Singapore's emissions will not dip below historical levels in the near future. Nonetheless, the Singapore Government will study how Singapore can stabilise our long-term emissions. Every Singaporean and resident can help do their part to reduce emissions by making informed decisions to reduce their resource and energy consumption.

Singapore's pledge to reduce emissions is a significant commitment for a resource poor and fossil energy-dependent city-state. Although we are a small country with minimal impact on global emissions, Singapore has a responsibility as a member of the global community to help address climate change.

In addition to our participation in global discussions, Singapore currently shares expertise in climate change and environment management with other countries, through training courses on a wide range of topics including sustainable urban development, water management and energy efficiency. Singapore is also a partner in a number of key bilateral initiatives such as our collaboration with China in the Sino-Singapore Tianjin Eco-city project, envisioned as a replicable, practical and scalable model for sustainable development for other cities in China and other parts of the world.

Singapore as a Climate Resilient Global City

Singapore has overcome many environmental challenges in its short history. Our vision is to be a climate resilient global city that is well positioned for green growth.

As a small city-state, Singapore's success and prosperity depends on being able to overcome the challenges of climate change and to grasp the opportunities it presents. We must nurture a vibrant and innovative economy, and achieve economic growth in a low carbon and sustainable manner through the development and deployment of clean energy and energy efficient technologies. This will enable us to develop a high quality environment and sustainable growth for the sake of our current and future generations.

Guiding Principles

These key principles guide our response to the challenges of climate change:

Long-Term and Integrated Planning
Climate change is a challenge which requires a response that is long-term, integrated and holistic. We must plan ahead, and accept that some short-term adjustments or costs may yield longer term benefits. For instance, our decision to clean up the Singapore River in 1977 was made at great financial and social cost. Industries and communities had to be relocated. Today, the Singapore River is part of the Marina Reservoir, a freshwater reservoir in the heart of the city. This would not have been possible without the long-term and integrated planning that is at the heart of Singapore's economic and environmental management. We must continue to take a long-term view towards assessing costs and benefits.

Pragmatic and Economically Sound Measures
Our goal is sustainable growth—to pursue economic and environmental objectives together, not one at the expense of the other, or either at all costs. We want Singapore to be an environmentally-friendly home in which current and future generations of Singaporeans can live, work and play. At the same time, our policies must be economically sound so that they are sustainable. Reducing emissions and sustaining economic development at the same time is a delicate balance that has to be made

consciously. We harness market forces and price signals, avoiding energy subsidies that consume fiscal resources, distort consumer behaviour and increase environmental pollution. By pricing energy at its market cost, we encourage households and businesses to use energy judiciously. We will consider economic and environmental costs and benefits, as well as human factors, when determining the most appropriate measures to reduce emissions and tackle climate change. As attitudes, behaviour and options change over time, our policies will also have to evolve. For instance, as technologies mature, the range of feasible energy alternatives available to Singapore could increase.

Developing Innovative Solutions for Singapore and Global Markets

Singapore has a potential role as a green growth hub. Our land and resource constraints are a potent impetus for us to be innovative and to invest heavily in resource efficient technologies. For example, Singapore reduced our dependence on imported water by developing NEWater (ultra-clean and high grade reclaimed water) technology. Over the last four decades, we diversified our water supply through strategic planning and investment in research and technology. We now have capabilities in water management, desalination and water reclamation technologies, and have exported our expertise worldwide. Our policies to address climate change should encourage and nurture our potential to develop solutions that can benefit the world.

Approach to Address Climate Change

Recognising that climate change affects the work and responsibilities of many Ministries and government agencies, the Government formed the National Climate Change Secretariat (NCCS) as a dedicated unit in July 2010 under the Prime Minister's Office to provide coordination at the highest level for Singapore's domestic and international policies, plans and actions on climate change. The NCCS also supports the work of the Inter-Ministerial Committee on Climate Change.

Singapore's approach to addressing climate-related challenges is four-fold:

First, reduce carbon emissions in all sectors. Through fuel taxes, controlling vehicle ownership and usage, energy efficiency incentives and other policies, Singapore has proactively reduced the growth of carbon emissions. There is scope to do more. In particular, we must continue to improve energy efficiency and minimise wastage of energy. Technology will play a key role in shaping Singapore's measures to mitigate emissions and waste. The Government is working with the academic and research community, as well as innovative companies, to assess and develop technologies addressing climate change that might be deployed in Singapore.

Second, be ready to adapt to climate change effects. To improve Singapore's resilience to climate change, we need to better understand its potential impact on Singapore, and formulate appropriate strategies to cope with climate-related changes. Companies will need to examine their business continuity plans to cope with disruptions from extreme weather events. The public will have to be mentally prepared for and learn to adapt to a changing environment and weather patterns.

Third, harness green growth opportunities. Singapore is well positioned to support the development and export of climate-friendly technologies, services and solutions. Our economic agencies' efforts to grow the clean energy, water and carbon services sectors have started to yield results. This builds on our strengths in engineering and sustainable urban management. We will strengthen our R&D capabilities and human capital with the help of our tertiary and research institutes, and provide opportunities for companies to develop and test innovative solutions here. A supportive business environment will help attract more investments in green industries, and encourage international and non-governmental organisations in the environmental and developmental areas to be based in and expand from Singapore. Singapore-based businesses are encouraged to develop solutions for deployment in Singapore and for

export to other countries. This will create high value jobs for Singaporeans and propel our economy along a green growth trajectory.

Fourth, forge partnerships. Our domestic efforts are complemented by international collaboration. Besides the UNFCCC discussions, Singapore participates in related multilateral efforts, including discussions hosted by the World Trade Organisation (WTO), the World Intellectual Property Organisation (WIPO), the International Maritime Organisation (IMO) and the International Civil Aviation Organisation (ICAO), in support of a holistic approach to deal with climate change. We are also actively engaged in environmental cooperation through regional and bilateral platforms such as the Asia-Pacific Economic Cooperation (APEC), the Association of Southeast Asian Nations (ASEAN), the C40 Cities Climate Leadership Group (C40) and the Sino-Singapore Tianjin Eco-city.

Domestic partnerships are just as important. The people, private and public (3P) sectors must work together to effect climate change action in Singapore. We have adopted a consultative approach towards environmental issues, including the development of the 2009 Sustainable Singapore Blueprint. Outreach programmes such as the 10% Energy Challenge and the President's Award for the Environment help to raise awareness and encourage behavioural change. Public engagement and participation builds a sense of shared purpose.

As part of the development of this Strategy document, and public engagement on climate change-related issues, the NCCS, together with relevant agencies, conducted consultations. The feedback from public forums and consultations has been positive and encouraging. In a national survey held in late 2011, 86% of participants felt responsible for helping to address climate change and 74% indicated concern over climate change. These responses reflect strong support for climate change action.

Realising Our Vision

Singapore must respond to the challenges of climate change as one nation. The Government will put in place the necessary policies, public investments, information and support to assist the transition to lower our emissions. However, much of what we can achieve as a nation will depend on the collective efforts of our businesses and people.

To succeed, our strategies cannot remain static. We must stay flexible, review the effectiveness of policies and measures, and plan ahead. Our national strategy will be updated as the world's knowledge of climate science and climate modelling improves. As we stabilise and reduce our emissions over time, we will ensure that Singapore remains resilient to the adverse effects of climate change, and continues to thrive in a changing world.

> Our vision for Singapore is a climate resilient global city that is well positioned for green growth... We need a whole-of-nation effort—involving the people, the private, and the public sectors to realise our vision. Together, we can ensure that Singapore remains a vibrant and liveable nation for our future generations.

DEPUTY PRIME MINISTER TEO CHEE HEAN DURING THE SINGAPORE PARLIAMENT COMMITTEE OF SUPPLY DEBATE, 1 MARCH 2012

CHAPTER 1

Climate Change and Why It Matters

Forest fire—a contributor and consequence of climate change.

Increased frequency of droughts, floods and forest fires—some of the effects of climate change.

As a small low-lying city-state, Singapore is naturally vulnerable to the effects of climate change. Accordingly, we have a deep interest in global efforts to address the impact and potential disruptions to human societies and ecosystems brought about by climate change. Scientists all over the world have yet to agree completely on many aspects of climate change: for instance, how severe the impact and consequences will be. Nevertheless, there are growing signs that our climate is changing—the unusual number and intensity of extreme weather calamities around the world may be a prelude to what is to come if no concerted action is taken.

We do not have the luxury of time to wait for debate on the causes of climate change to be fully settled before we proceed. We have to rely on the best prevailing scientific consensus to prepare for the risks of a challenging and uncertain future.

At the same time, climate change is a global challenge that requires global action. No nation can solve the problem on its own, and a multilateral approach is essential. International negotiations will take time, as any global agreement has to be acceptable to all countries, which have different capabilities and circumstances.

What is Climate Change?

The earth's climate is a complex system that encompasses many weather-related variables such as surface and atmospheric temperature, humidity, wind, precipitation and sea levels.

According to the United Nations' Intergovernmental Panel on Climate Change (IPCC),[7] **climate change** refers to statistically observable variations in the state of the climate that persist for an extended period (usually decades or longer). This can manifest as an increased incidence of heat waves, heavy rainfall and extremely high sea levels.

The global scientific consensus is that climate change is the outcome of a complex array of natural and man-made processes and effects, including human activities such as the burning of fossil fuels to produce energy and goods for daily use, the clearing of forests and the rearing of livestock. The resultant greenhouse gas emissions cause the enhanced greenhouse effect and lead to climate change. While there are sceptics arguing whether climate change is solely attributable to human activities, there is a consensus that the climate is indeed changing, as can be observed through higher global average temperatures, the receding of polar ice-caps, and the increased intensity and frequency of extreme weather events. If carbon emissions from human activities continue to grow unchecked, climate change is projected to accelerate. However, the scale and pace of this acceleration will depend on a large number of variables and relationships (not all of which are fully understood). The IPCC publishes periodic reports on the earth's climate.

The IPCC's most recent Fourth Assessment Report (AR4) in 2007 stated that most of the observed increase in globally averaged temperatures since the mid-20th century is very likely (>90% probability) due to the observed increase in human greenhouse gas concentrations since the Industrial Revolution in the 1800s, when fossil fuels, predominantly coal, were burnt to provide energy. The increase in the use of fossil fuels for human activities is a major determinant of the pace of climate change.

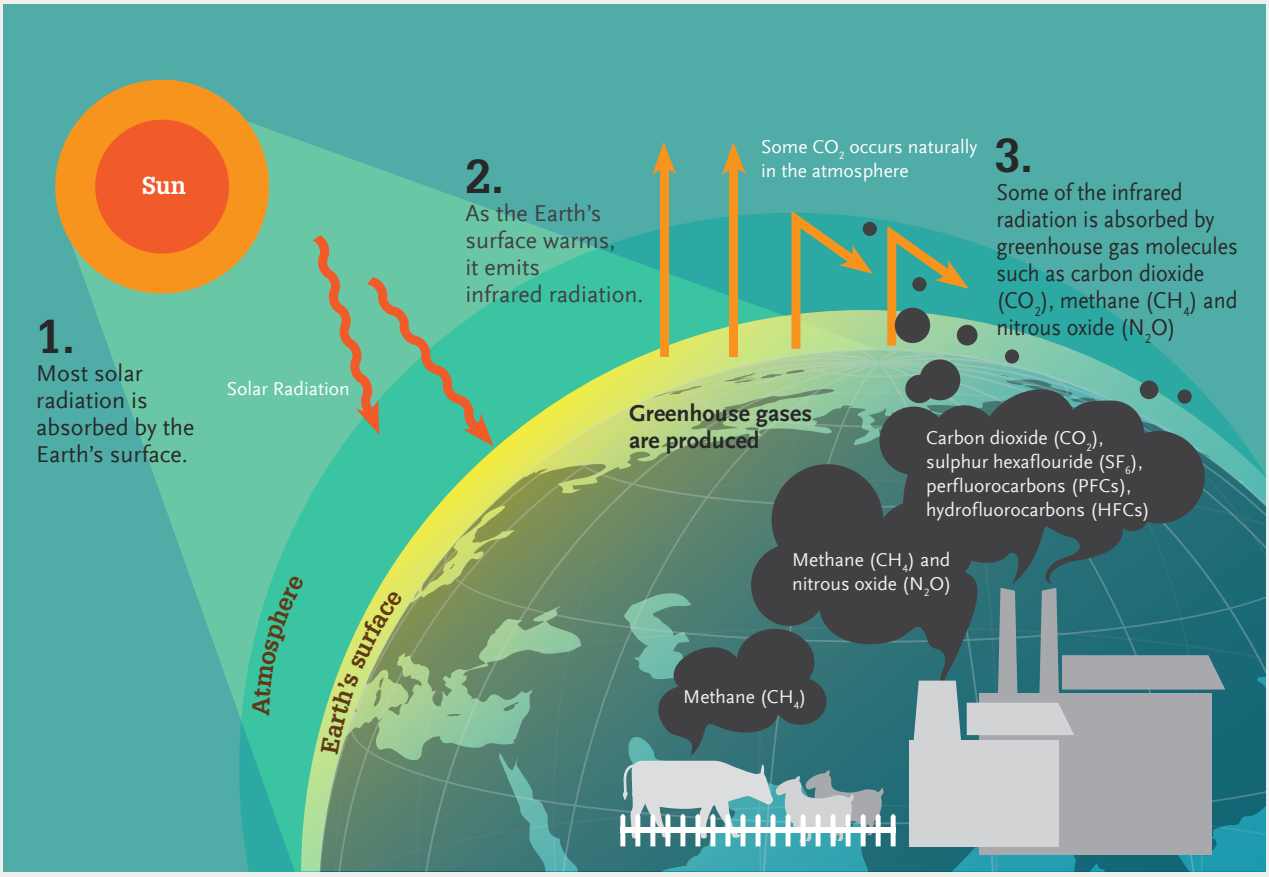
[7] The IPCC (http://www.ipcc.ch) draws on hundreds of scientists providing a range of expertise and geographical representation to produce periodic reports on its assessment of scientific studies related to climate change.

What is the Enhanced Greenhouse Effect?

Heat from the earth's surface is absorbed by greenhouse gases in the air and gets trapped within the earth's atmosphere. This phenomenon is known as the greenhouse effect, similar to the trapping of heat in greenhouses during cold weather.

The *greenhouse gases*—carbon dioxide, methane, nitrous oxide and fluorinated gases—form a very small proportion of the atmosphere. For example, carbon dioxide makes up only 0.3% of air. However, some of these gases can remain in the atmosphere for hundreds of years. These gases accumulated over time can cause surface temperatures of the earth to warm considerably.

Many of our everyday activities—including transportation, lighting and air-conditioning, cooked food and cold beverages, household appliances and mobile devices—rely on energy. The combustion of fossil fuels, both directly and for electricity generation, releases trapped carbon into the atmosphere. The build-up of greenhouse gases in our atmosphere through human activities, leads to the *enhanced greenhouse effect*. The clearing of forests also reduces the "green lungs" that absorb greenhouse gases during photosynthesis.



Why Does Climate Change Matter?

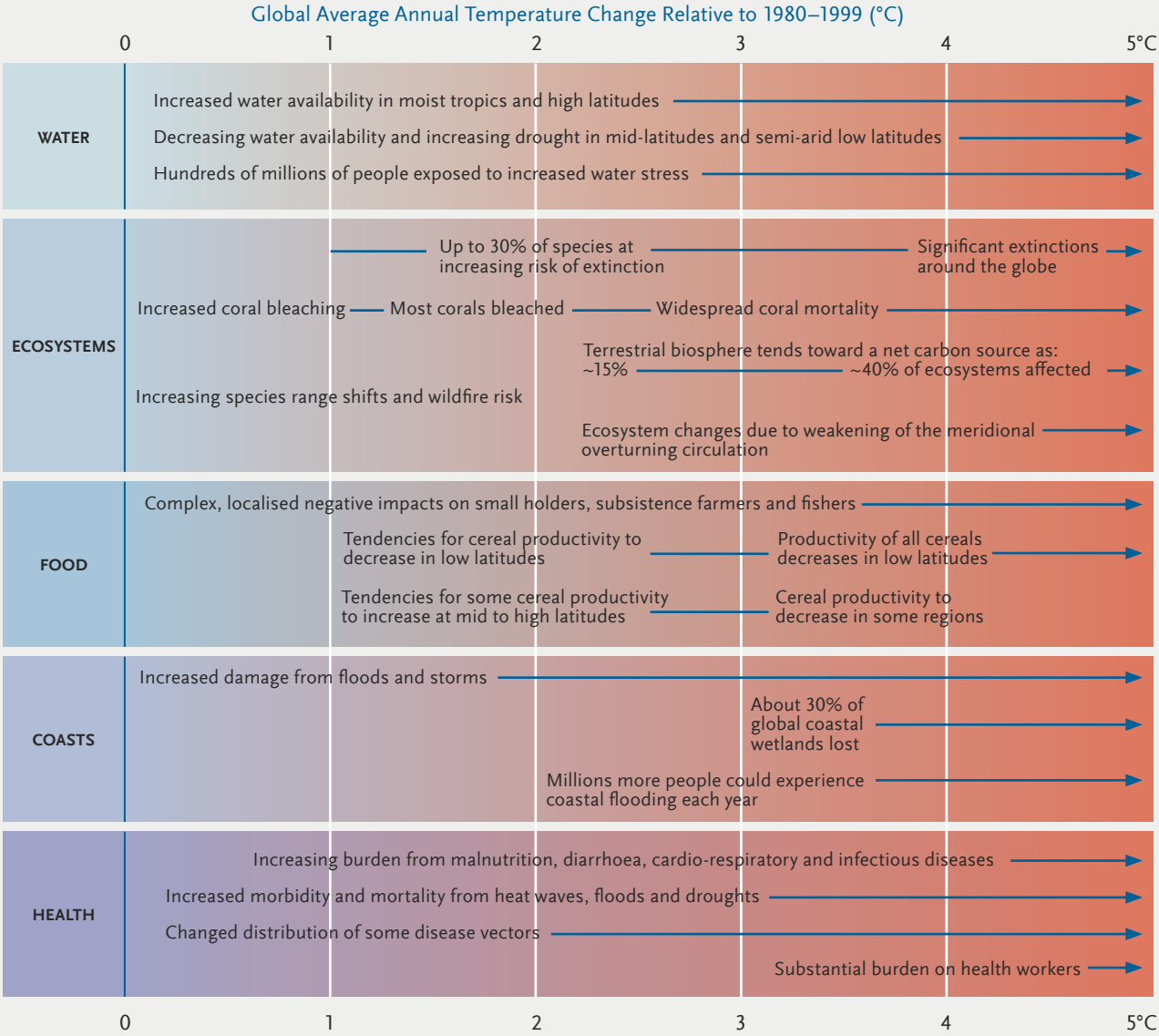
The earth's climate has a powerful influence on practically every physical, ecological and biological system on the planet.

According to the IPCC's AR4, anthropogenic warming due to human activities and sea level rise could continue for centuries, due to the accumulation of greenhouse gases in the earth's atmosphere since the 19th century. World temperatures could rise by between 1.1°C and 6.4°C this century. Sea levels could rise by between 0.18m and 0.59m. For Southeast Asia, the temperature is expected to rise by 1.7°C to 4.4°C and sea level changes are similar to the global projections.

This is significant because even relatively small increases in global average temperatures over an extended period of time can have significant impact on the sustainability of water and food supplies, ecosystems, the stability of coastal zones and public health. For example, there will be increased damage from storms when the global average annual temperature increases by 2°C relative to the period between 1980 and 1999. With an increase of 3°C, there will be increased mortality from heat waves, droughts and floods, with hundreds of millions more people exposed to increased water shortages. Beyond a 3°C increase, changes in disease vectors will lead to increased burden on health services from cardio-respiratory and infectious diseases. Productivity of crops is expected to decrease in all regions at a temperature rise of 4°C with significant disruptions to ecosystems, leading to an overall loss of food supplies worldwide. For a detailed illustration of the impact associated with global average temperature change, see Figure 1.1.

In Singapore, the annual mean surface temperature has risen from 26.8°C in 1948 to 27.6°C in 2011. The mean sea level in the Straits of Singapore has increased by about 3mm per year over the past 15 years alone, and we can expect further changes. Rainfall has also been more intense in recent years. In 2001, the first recorded cyclone near the Equator, Typhoon Vamei, swept just north of Singapore and caused major floods in the region. It is uncertain whether such tropical cyclones near the Equator will occur more frequently in the future. In addition, countries from which we import food may experience extreme weather events such as intense storms, flooding and prolonged droughts. Extreme weather events also lead to travel disruptions, and impact business supply chains. Clearly, Singapore cannot be completely insulated from the impact of climate change.

Figure 1.1: Examples of Impact Associated with Global Average Temperature Change
(Impact will vary by extent of adaptation, rate of temperature change and socio-economic pathway)



Source: Figure SPM.7. Summary for Policymakers. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

What Makes Climate Change Difficult to Address?

Climate change has characteristics that make it more challenging than other major issues to address:

It involves trade-offs between the present and future
There might be upfront costs such as investments in energy efficient equipment and low-carbon energy technologies. But the real impact of such efforts to address climate change will only be more apparent in the long term. The impact will also depend on efforts being made across sectors, communities and individuals now.

The climate is a complex adaptive system
We need to address climate change early as effects can be felt long after their causes. Climatic changes can create feedback loops and reinforce each other, resulting in a vicious cycle. For instance, rising temperatures cause more rapid melting of the polar ice caps. This exposes the darker ground beneath the ice, which absorbs more heat from the sun, warming the area further and causing even more rapid melting of the ice.

Many of these effects such as ecosystem destruction are not easily reversible, and greenhouse gases can remain in our atmosphere for a very long time.

International and trans-boundary nature of climate change
Addressing climate change involves coordinated and collective action across many countries which are party to the United Nations Framework Convention on Climate Change (UNFCCC). There are also non-state actors such as businesses, international organisations and non-governmental organisations, representing diverse constituencies, interests and priorities. Given different needs and circumstances, it is a major challenge to secure, sustain and enforce a set of effective long-term agreements across such a large number of parties.

The Global Response to the Climate Change Challenge

The findings from climate science have driven the nature and pace of international negotiations on climate change, given the need for global action.

Adoption of the UN Framework Convention on Climate Change

The IPCC's First Assessment Report in 1990 underscored the seriousness of climate change, and linked the emissions from human activities to the additional warming of the earth's surface beyond natural effects.

The draft of the Framework Convention was deliberated at the UN Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, and the preparatory committee of UNCED and the Main Committee of the Rio meeting was chaired by Singapore's Ambassador-at-Large Tommy Koh. It led to the landmark UNFCCC adopted by the United Nations.

The framework requires governments to develop policies and strategies to reduce greenhouse gas emissions within their national boundaries and adapt to irreversible climate change.

The Convention on Climate Change enjoys near universal membership, making it one of the most universally supported international agreements under the UN.

From the Kyoto Protocol...

1996
IPCC Second Assessment Report noted the increase in greenhouse gas concentrations and evidence suggested a discernible human influence on the climate.

1997
Kyoto Protocol negotiated; 41 developed countries (Annex I Parties) agreed to binding targets for emissions reductions from 2008 to 2012.

2005
Kyoto Protocol came into effect.

2007
Bali Road Map established a new negotiating track to finalise a binding climate agreement involving all Parties.[8]

2009
Copenhagen Climate Conference did not reach consensus but a number of developed and developing countries announced targets on emission reduction efforts up to 2020.

2010
Cancun Agreements formalised the reduction pledges and adopted decisions on mitigation, adaptation, finance, technology and REDD+ (Reducing Emissions from Deforestation and Forest Degradation).

...to the Durban Platform for Enhanced Action

At the recent UN Climate Change Conference in Durban in 2011, there was agreement on a second commitment period of the Kyoto Protocol. This was significant as it provided for the continuation of a multilateral rules-based system for emissions reductions. Separately, the mitigation pledges by the developed and developing countries so far were also recognised to be insufficient in limiting the rise in global average temperature to 2°C—countries that have not pledged emissions reductions were encouraged to do so, and a work programme is underway to deepen existing efforts for all countries so that global emissions can be further reduced. Countries have agreed to start negotiations on a new climate change framework for the post-2020 period. This will require all countries to do more to reduce their emissions. The Durban conference also agreed on a package of key decisions, including the setting up of a Green Climate Fund to channel climate-related finance resources for developing countries to reduce emissions and to adapt to climate change.

Deputy Prime Minister Teo Chee Hean delivering Singapore's National Statement at the UN Climate Change Conference in Durban on 7 December 2011. DPM Teo reaffirmed the importance of a collective commitment to a multilateral rules-based system to deal with climate change.

[8] There are currently 195 Parties to the UNFCCC, which have ratified or acceded to the Convention. Singapore ratified the Convention in August 1997.

How Should Countries Contribute to the Global Effort?

All countries should contribute to this mitigation effort, bearing in mind the UNFCCC principle of common but differentiated responsibility (CBDR) and respective capabilities.

Historical Emissions

The concept of CBDR recognises that while combating climate change is a "common concern" for all countries, there should nevertheless be "differentiated responsibilities". Developed countries are largely responsible for historic emissions and the build-up of these greenhouse gases in the atmosphere since the beginning of the Industrial Revolution. The developed countries shoulder a greater responsibility for reducing emissions than developing countries. For example, the USA and the European Union (EU) cumulatively account for over 50% of all greenhouse gases emitted from 1850 onwards. However, given the diversity of each country's stage of development, be it size, resource endowment and characteristics, there is no straightforward and one-size-fits-all formula in considering what their individual contributions should be.

For example, should the principle be "polluter pays", that is, the more a country pollutes, the more it mitigates or pays? Likewise, should the notion of historical responsibility require developed countries to make up for historical emissions under the new climate regime? How do we normalise mitigation responsibilities across countries given wide variances in country characteristics and circumstances? How do we ensure that emission reduction efforts do not result in undue carbon leakage through the relocation of facilities to countries with lower emission reduction standards?

Absolute Emissions

The global community pays close attention to absolute emissions because it is the most important indicator reflecting the greenhouse gases released into the atmosphere that affect the magnitude and pace of global warming and climate change. Empirically, a few major economies produce the majority of global emissions. Out of the 195 signatories to the UNFCCC, the top twenty emitters account for more than 80% of global greenhouse gas emissions. In addition to international negotiations covering all the countries in the world, efforts by these countries will play a crucial role in addressing climate change (see Table 1.1).

Table 1.1: Estimated Greenhouse Gas (GHG) Emissions by Country (2005)

Country	GHG Emissions ($MtCO_2e$)	% of World total
China	7,195	16.7
USA	6,784	15.7
European Union (27)	5,047	11.7
Brazil	2,841	6.6
Indonesia	2,036	4.7
Russia	1,998	4.6
India	1,865	4.3
Japan	1,349	3.1
Canada	806	1.9
Mexico	671	1.6
Iran	568	1.3
South Korea	568	1.3
Australia	561	1.3
Ukraine	494	1.1
Venezuela	453	1.1
Nigeria	451	1.1
Turkey	425	1.0
South Africa	423	1.0
Saudi Arabia	375	0.9
Malaysia	368	0.9
Total		81.7

Figures take into account carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons(PFCs), hydrofluorocarbons (HFCs) and sulfurhexafluoride (SF_6) emissions, and emissions from land-use, land-use change and forestry.

Source: Climate Analysis Indicators Tool (CAIT) Version 9.0. (Washington, DC: World Resources Institute, 2012).

As a highly urbanised city-state vulnerable to the adverse effects of climate change, Singapore has a deep interest in global efforts to address the effects of climate change. Since independence, Singapore has balanced economic and environmental goals, despite being a fossil energy- and trade- dependent city-state with limited access to alternative energy options. Whilst Singapore contributes less than 0.2% of global emissions, we have and will continue to play our part in global efforts to combat climate change.

Carbon Intensity

Some officials and scholars have suggested normalising countries' emissions by *economic value-add* or *GDP* (i.e., CO_2 emissions per dollar GDP) to facilitate international comparisons, i.e., carbon intensity. This indicator is useful in highlighting the efficiency of countries in generating GDP vis-a-vis their carbon emissions. If carbon efficiency is not taken into account, global emissions could increase as economic activity relocates from a more carbon efficient country to a less efficient one.

Singapore ranks favourably, near the lowest (123rd of 137 countries), in terms of CO_2 emissions per dollar GDP based on International Energy Agency (IEA) data.[9]

Per Capita Indicators

Others have proposed using per capita indicators as the basis for normalising absolute emissions to take into account population size (i.e., CO_2 emissions per capita) and hence determine each country's "fair" share of emissions reductions and financial contributions to support the fight against climate change.

Whilst this indicator is generally favoured by countries with large populations, other countries have also pointed out that emissions per capita is neither an appropriate primary measure nor reflective of a country's mitigation responsibilities.[10] For countries with small populations, the carbon emissions per capita indicator will naturally tend to be higher. Small countries are also less able to leverage on economies of scale and low-carbon renewable energy sources that require space and land. For example, Singapore is a city-state that has no readily available alternative energy sources and is therefore heavily dependent on imported fossil fuels. Per capita indicators do not reflect the circumstances of many small countries. Singapore ranks 27th out of 137 countries in terms of emissions per capita based on the latest IEA data.

There is no international consensus on which indicators best reflect the respective responsibilities of countries in the global effort to reduce carbon emissions. Nonetheless, given the magnitude of the challenge, all countries, developed or developing, should contribute to global action to address climate change in accordance with their national circumstances.

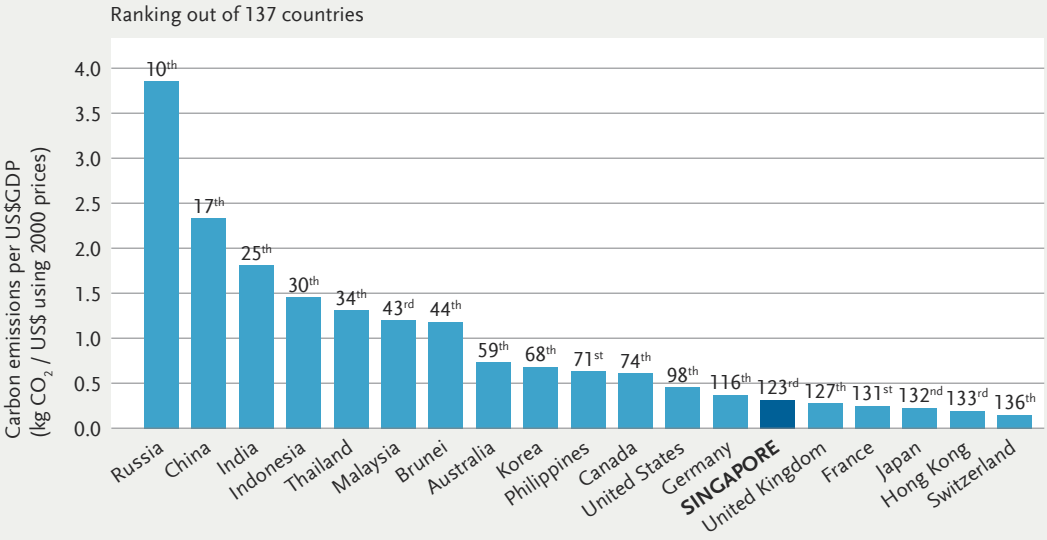
Comparing Greenhouse Gas Emissions

In the following graphs, the International Energy Agency's data on carbon emissions from fuel combustion is used. This excludes emissions from areas such as land use, land-use change and forestry, and industrial processes.

[9] For 2009, which is the most recent year available.

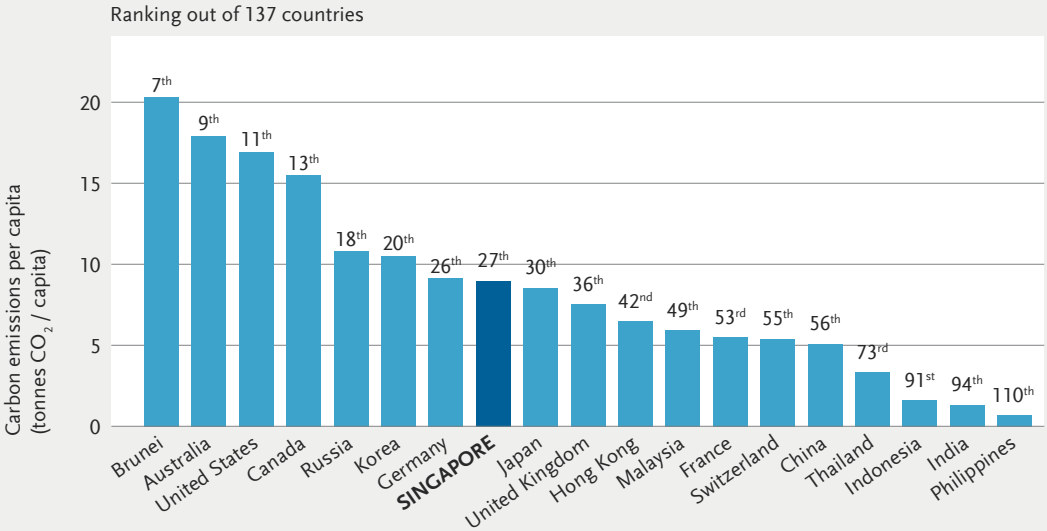
[10] The considerations that follow also apply to computations on carbon footprint per capita, which attributes carbon emissions in the production of goods to the importing country. This would entail holding the importing country responsible for the emissions in the production of the goods overseas.

Figure 1.2: Carbon Emissions (from Fuel Combustion) Per US$GDP (2009)[11]



Source: CO_2 Emissions from Fuel Combustion—2011 Highlights © OECD/ International Energy Agency, 2011.

Figure 1.3: Carbon Emissions (from Fuel Combustion) Per Capita (2009)



Source: CO_2 Emissions from Fuel Combustion—2011 Highlights © OECD/ International Energy Agency, 2011.

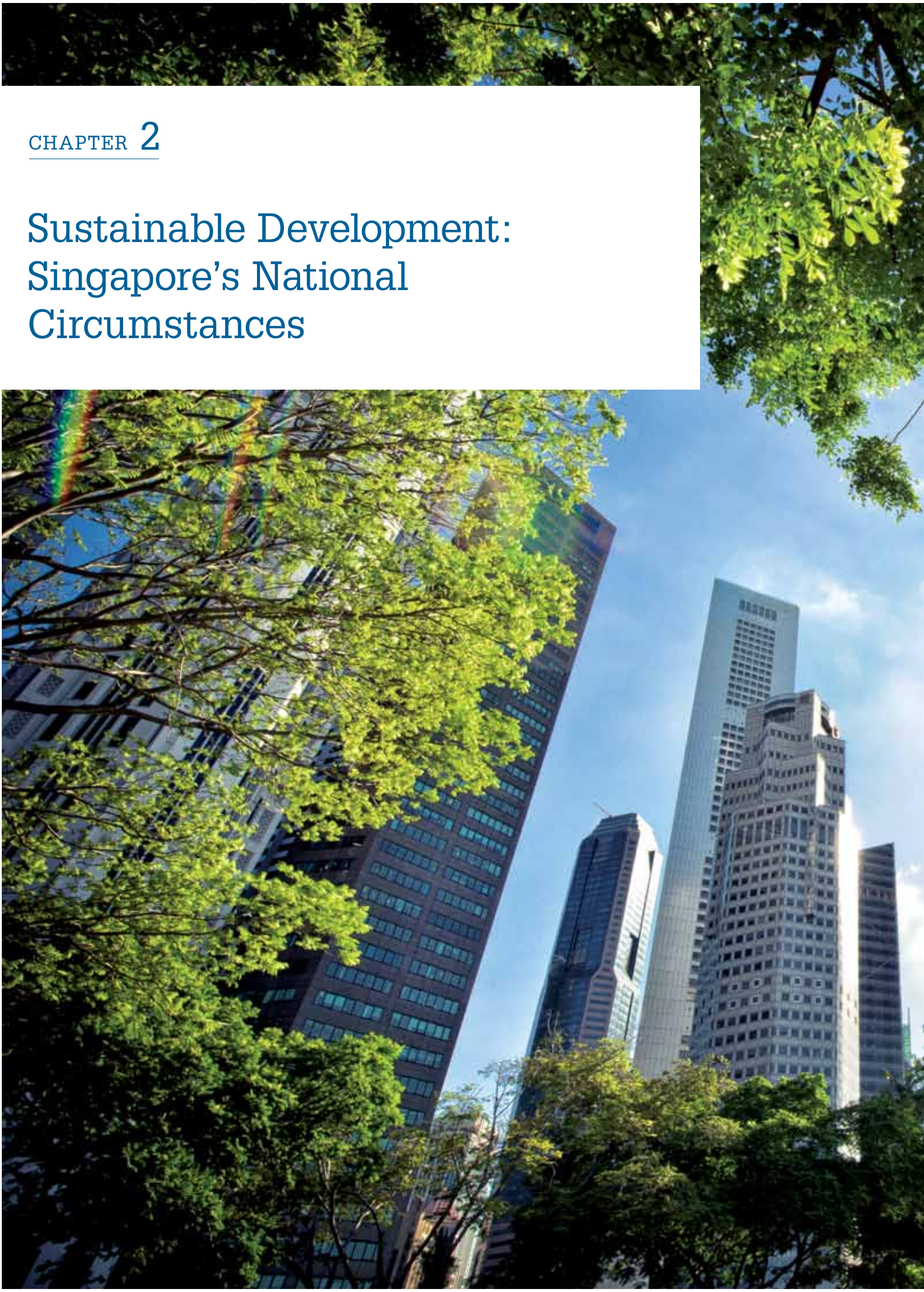
Conclusion

The climate is changing, and this can severely impact the global environment and ecosystems. Singapore is committed to the multilateral system embodied by the UNFCCC process to address the global climate change challenge, and will do our part.

[11] Countries represented in the chart are selected from Singapore's major trading partners and key economies in their respective world regions.

CHAPTER 2

Sustainable Development: Singapore's National Circumstances



Singapore's Central Business District has extensive greenery.

Naturalised river meandering through the newly-revamped Bishan-Ang Mo Kio Park—a project undertaken by PUB under the Active, Beautiful and Clean Waters (ABC Waters) Programme.

In a world where rapid industrialisation and urbanisation have put pressure on environmental and water resources, countries face the constant challenge of balancing economic development with environmental considerations.

Singapore has always appreciated the importance of sustainable development, resource conservation and optimisation, and integrated urban planning. At the same time, we recognise that strong economic growth is necessary to generate the resources and capabilities needed to deal with climate change and its potential impact.

This approach will stand us in good stead as we confront a changing climate.

A History of Sustainable Development for Singapore

A high-quality living environment has long been an important priority for Singapore. Our development as a clean and green city is the result of decades of deliberate planning and efforts since independence in 1965, before climate change became a global concern. A quality living environment enhances Singapore's living standards as well as our attractiveness to investments that grow our economy and provide jobs. A clean environment with low pollution also reduces health and related problems for our people. A well-tended environment is an ongoing investment that will benefit our current and future generations.

Singapore's Ministry of the Environment was established following the United Nations' first major conference on international environmental issues in Stockholm in 1972. We were one of the very first countries with a Ministry dedicated to creating and sustaining a desirable environment. We took further steps to develop in a sustainable way during our early decades of economic growth. The Singapore Green Plan, setting out early goals and initiatives balancing developmental needs with environmental considerations, was presented at the Earth Summit in Rio de Janeiro, Brazil in 1992.

Singapore—The City in a Garden

One of the cornerstones of Singapore's sustainable growth efforts is our strategy of integrated long-term land use planning. As an island city-state with an area of 710km^2 and resident population of 5.2 million people in 2011, land is a scarce and precious resource in Singapore. Our urban planning process reflects the need to optimise our limited land area.

Our integration of economic, social and environmental goals is reflected in innovative initiatives to build and extend green spaces within our highly urbanised environment. Singapore aspires to be a City in a Garden.

Almost 50% of Singapore is covered in greenery, which compares very favourably with major cities around the world. Despite land constraints, close to 10% of Singapore's land is set aside for parks and nature conservation.

We are encouraging the use of vertical greening and rooftop gardens for buildings to absorb heat and lower building temperatures, and mitigate the urban heat effect, thus saving energy for cooling.

Major parks and green spaces around the island are being linked through an extensive Park Connector Network. Under the Active, Beautiful and Clean Waters (ABC Waters) Programme, PUB is also transforming our reservoirs and waterways into beautiful and clean streams, rivers and lakes, creating new spaces for recreation and community bonding.

We also plan to build the Round Island Route, a seamless green corridor around Singapore that spans more than 150km or three times the length of Singapore. The new Gardens by the Bay, which comprises three distinctive gardens, will be located on prime waterfront land in the Marina Bay. Its flagship garden, Bay South, will officially open in mid-2012. This signature project in the heart of our new Marina Bay financial district reflects our strong commitment towards greening our city.

Park connectors to link our green spaces.

A Planned Environment

Singapore's land use and transportation plans for the next 40 to 50 years are outlined in the **Concept Plan**, which is reviewed every 10 years to take into account changing economic and social needs.

This long-term strategic plan is used to develop a clear and transparent medium-term **Master Plan**, which guides development over the next 10 to 15 years.

New projects in key development areas in City Centre, Jurong Lake District, Kallang Riverside and Paya Lebar Central are required to meet high standards for environment sustainability.

Urban planning is carefully integrated with transport planning to reduce the need for and the distance of commuting, and to provide convenient access to public transportation. The modal share of public transport is 59% and the goal is to increase this to 70%.

Managing Private Transport and Making Public Transport a Choice Mode

Singapore has one of the world's most stringent and innovative systems to manage private transport demand. Car ownership is controlled through a quota system and car usage is managed through road pricing in the city centre, on highways and key roads. These measures were introduced to manage traffic congestion, and have helped to reduce vehicle emissions in Singapore.

We are also encouraging more people to switch from private to public transport, which is a more energy-efficient mode of travel. The Government has committed some S$60 billion to enhance the capacity of existing Mass Rapid Transit (MRT) rail lines and to implement new rail lines. This hefty investment is expected to double Singapore's rail network from 138km in 2008 to around 280km by this decade to increase its reach and accessibility. To enhance the capacity of existing lines, additional trains are being purchased. The signalling system of the North-South and East-West Lines is also being upgraded to further shorten headways between trains.

Continuing improvements are also being made to bus services. Higher-capacity buses and additional bus trips have been introduced. Buses now enjoy greater priority on the roads with increased coverage of full-day and part-day bus lanes, and the Mandatory Give Way to Buses scheme across the island. In addition, the Government will partner the public transport operators to grow the existing public bus fleet significantly by about 800 buses (or 20%) over the next 5 years. This will raise existing bus service levels, and enhance the capacity and connectivity of the bus network, thus improving the overall quality and attractiveness of the public transport system.

Key Levers to Manage Private Transport Demand

Vehicle Ownership: The Vehicle Quota System (VQS) was implemented in May 1990 to control the vehicle population by limiting the maximum number of new vehicles registered in Singapore each year. Those wanting to register a new vehicle would need to bid for a Certificate of Entitlement (COE), which entitles the person to own and use the vehicle for 10 years. The COE quota is calculated based on the vehicle population that is assessed to be sustainable in the long term. Under the VQS, Singapore limited its annual vehicle growth rate to 3% between 1990 and 2008, and progressively reduced this rate to 1.5% (2009 to 2011), 1% (2012) and 0.5% (2013 onwards). For the cost of a typical mid-sized car, see Table 2.1.

Vehicle Usage: Whilst VQS manages vehicle population, the Electronic Road Pricing (ERP) manages usage by levying a charge on vehicles using congested portions of roads, thereby encouraging motorists to either use alternative routes, travel at a different time, or switch to public transport. In addition, a fuel excise duty of S$0.41 to S$0.44 per litre of petrol is levied, depending on the fuel grade.

Table 2.1: Purchasing a Typical Mid-Sized Car with 1600cc Engine Capacity (in S$)

Open Market Value (OMV)	$15,000
Excise / Customs Duty (20% OMV)	$3,000
Goods and Services Tax (7%)	$1,260
Registration Fee	$140
Additional Registration Fee (ARF) (100% OMV)	$15,000
Certificate of Entitlement (varies, assume average 2011 COE premiums)	$48,000
Total	$82,400*

*Under the Carbon Emissions-based Vehicle (CEV) Scheme (see Chapter 3), a car buyer may further enjoy a rebate off the ARF or have to fork out a surcharge depending on the emissions performance of the car.

Source: Ministry of Transport.

Electronic Road Pricing manages traffic demand on our roads.

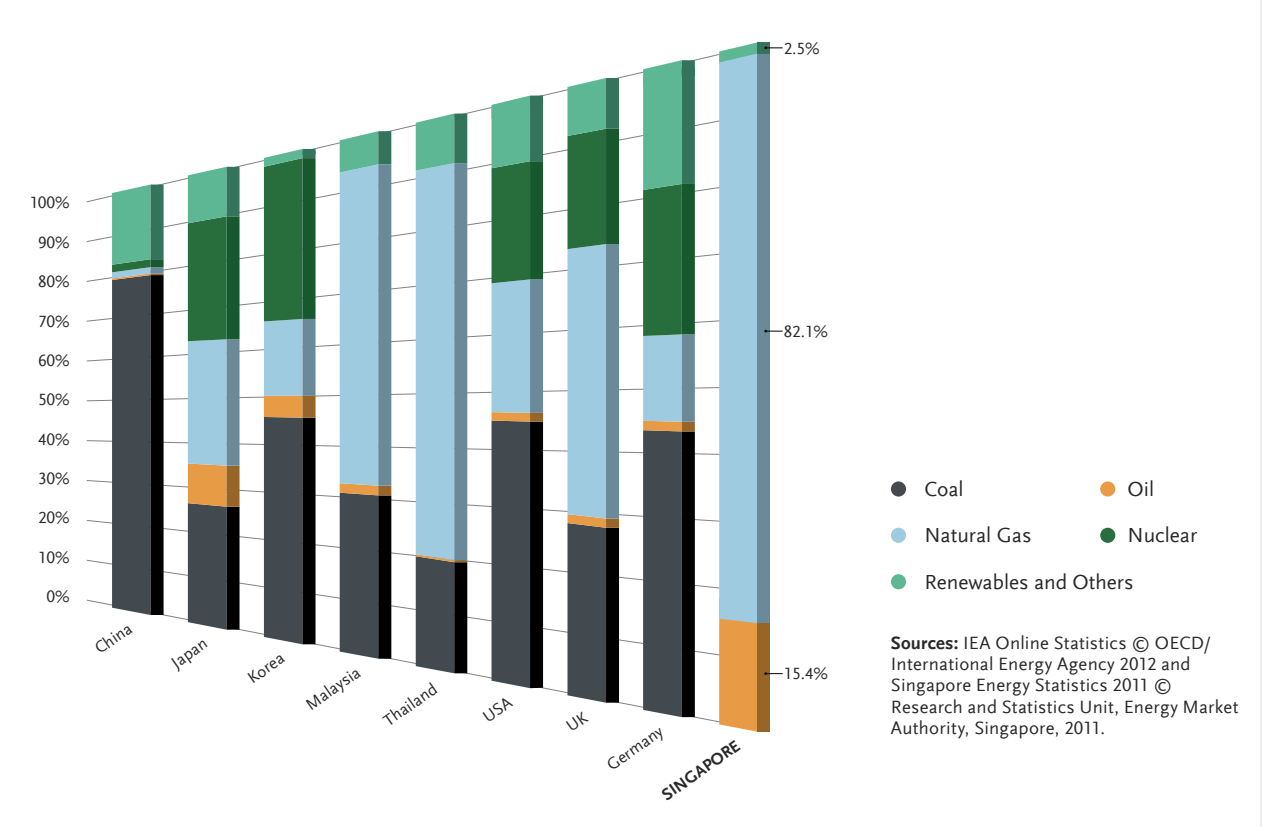
Power Generation— Lowering the Carbon Content of Our Fuel

Power Generation is one of the major sources of carbon emissions for any country. With limited alternative energy resources, Singapore relies on imported fuel to power our daily activities. Many of our early policy decisions have helped to reduce emissions from our energy sector.

The following are some examples:

- Singapore chose not to use coal for electricity generation in our early years of economic development despite its availability and lower price.
- Unlike many other countries, Singapore has avoided subsidising energy use. By pricing energy at rates that reflect its market cost, we encourage households and businesses to use energy prudently.
- Singapore has switched from fuel oil to natural gas as our main energy source for electricity generation. Natural gas produces the least carbon emissions per unit of electricity generated amongst fossil fuel-fired power plants. By increasing the share of natural gas used in electricity generation, from only 19% in 2000 to about 80% today, we have substantially reduced our emissions growth. Compared with other countries, where coal is still a key component of their fuel mix, Singapore is relatively less carbon intensive (see Figure 2.1).

Figure 2.1: Fuel Mix for Power Generation by Country (2009)



Sources: IEA Online Statistics © OECD/ International Energy Agency 2012 and Singapore Energy Statistics 2011 © Research and Statistics Unit, Energy Market Authority, Singapore, 2011.

National Circumstances and Constraints

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

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

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

As Singapore is a small, alternative-energy disadvantaged city-state, there will be limitations to the extent of emissions reductions that can be undertaken. Given our small size and dense urban landscape, there are challenges to use alternative energy sources such as solar energy on a wide scale. Such difficulties in switching to alternatives are recognised by the UNFCCC.[12]

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

Solar panels on a public housing block at Jurong East Street 24.

[12] 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".

Singapore's Limited Access to Alternative Energy Sources

Hydroelectric power
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.

Marine renewable energy (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. The availability of wave power is determined by height and frequency of the waves, but the waters around Singapore are relatively calm as we are sheltered by land masses.

Geothermal energy
Geothermal energy is not commercially viable in Singapore given the lack of conventional geothermal resources and our small land area.

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.

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

Nuclear
While nuclear energy is a source of low-carbon electricity, there are considerable challenges given Singapore's small land area and high urban density.

Solar
Although Singapore is located in the tropics, there are challenges to harnessing solar energy given our small size and dense urban landscape.

> "As a small country, there are inherent limitations to what we can do to reduce emissions. We face significant constraints in switching to alternative or renewable energies, such as geothermal, wind or hydropower, to reduce our dependence on fossil fuels. We are an 'alternative-energy disadvantaged country'... The past actions we have already taken to conserve energy have also limited our potential to further reduce emissions."

THEN-SENIOR MINISTER S JAYAKUMAR ON 2 DECEMBER 2009 AT A MEDIA INTERVIEW

Asia's Greenest City

The Asian Green City Index[13] is one example of how Singapore is well regarded internationally for our living environment. According to the 2011 Asian Green City Index, Singapore is Asia's greenest metropolis, and the only city assessed to perform well above average in the overall rankings. Highlighting our sound policies as well as our achievements in efficient energy use, the study also cited Singapore for "having an energy reduction strategy, for making efforts to consume energy more efficiently, for having a climate change action plan and for signing up to international environmental covenants".

In the World Economic Forum's Global Competitiveness Report 2011–2012, Singapore ranked second in both the Global Competitiveness Index and the newly introduced Sustainable Competitiveness Index, which takes into account countries' environmental policy, resource efficiency and environmental degradation, alongside other economic and social indicators. Singapore also ranked third overall in the Economist Intelligence Unit's "Global City Competitiveness Index" in 2012 and is the highest placed Asian city. The report highlighted Singapore's focus on environmental sustainability as a key aspect of liveability, which was emphasised very early on from the 1960s.

However, given that Singapore imports most resources—ranging from fuel to food and water—our "carbon footprint" has been noted in studies such as the World Wide Fund for Nature's 2010 Living Planet Report. While per capita indicators are inherently higher for small countries and do not consider national circumstances, Singapore recognises that we can do more to reduce resource use and waste generation.

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

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

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

Conclusion

Singapore's twin goals of growing our economy and protecting the environment remain central to our national strategy. We will continue to take steps to reduce our carbon emissions, building on past mitigation efforts. How much we can do also depends on our national circumstances, geographical constraints, and the extent to which Singapore can harness non-fossil fuel alternatives.

[13] The Index and accompanying study were commissioned by Siemens and developed by the Economist Intelligence Unit (EIU). It examined the environmental performance of 22 major Asian cities in eight categories: energy and carbon dioxide (CO_2), land use and buildings, transport, waste, water, sanitation, air quality and environmental governance. The EIU developed the methodology with leading urban experts around the world, including representatives of the Organisation of Economic Co-operation and Development, the World Bank and Asia's regional network of local authorities, CITYNET.

CHAPTER 3

Mitigation: Reducing Emissions

Sakra Natural Gas Station on Jurong Island.

Henderson Waves, standing at 36m above Henderson Road, connects Mount Faber Park to Telok Blangah Hill Park.

Singapore needs to play our part to reduce greenhouse gas emissions, as the world responds to the looming threat of climate change.

Singapore has pledged to reduce emissions by 16% below 2020 business-as-usual (BAU) levels[14] if there is a legally binding global agreement in which all countries implement their commitments in good faith. Ahead of this, Singapore has embarked on policies and measures that will reduce our emissions by 7% to 11% below 2020 BAU levels. This is a challenging target, given our limited access to alternative energy solutions that may reduce emissions on a significant scale. Therefore, a key thrust of our mitigation measures is to improve energy efficiency. Although this will require our households and businesses to be more energy conscious and make adjustments to their daily activities, choices and processes, there will be cost savings as a result of reducing energy consumption.

[14] The BAU level refers to a projection without policy intervention. It also refers to a "without measures", "baseline" or "reference" projection.

Singapore's Approach to Reducing Emissions

Energy is a strategic resource for Singapore, and we are almost completely reliant on external sources of fuel to produce energy to meet our needs. We price fuel and electricity according to market supply and demand, and avoid subsidising energy costs. By pricing energy according to what it is worth, firms and households can make appropriate choices, minimise energy wastage and over-consumption.

As the vast majority of carbon emissions originate from the combustion of fossil fuels for energy, the most direct way to reduce emissions is to cut down the use of fossil fuels. While we are actively supporting research on clean energy technologies, Singapore has limited access to alternative or renewable energy. We have taken the next best step, which is to switch from fuel oil (more carbon-intensive) to natural gas, which has a lower carbon content per unit of electricity generated. However, there are limits to how much more we can reduce emissions by switching fuels, since natural gas already constitutes around 80% of our fuel mix for electricity generation today.

Energy Efficiency as a Core Strategy

Given Singapore's limited access to renewable energy, energy efficiency is our core strategy to reduce emissions. Singapore needs to further enhance energy efficiency across all sectors of the economy. Our objective is to achieve, by 2030, a 35% reduction[15] in economy-wide energy intensity, i.e., the amount of energy required to produce each S$GDP.

Conceptually, the most economically efficient approach would be to rely on market forces and price signals, prioritising measures for which the benefits (in the form of life cycle energy savings) exceed the cost of implementing the measures. However, the effects of these policies can be complex. For instance, it is not always possible to accurately predict how much carbon abatement will result from particular measures, as those affected may respond in different ways. Singapore is therefore conducting pilot trials where appropriate to assess feasibility for larger scale implementation.

The Singapore Government will help to raise awareness and build capabilities to improve our energy efficiency. A major part of this effort involves addressing sector-specific barriers using incentives or regulatory measures where appropriate.[16] Some of these policy options are illustrated in Figure 3.1.

[15] From 2005 levels.

[16] For instance, the proportion of 3- to 4-tick common household electrical appliances such as refrigerators and air-conditioners sold in Singapore have increased significantly; and less efficient 0- to 1-tick ones are no longer allowed for sale. This process of shifting the market towards more energy efficient appliances started with voluntary labelling on the energy consumption of these appliances in 2002, before labelling was made mandatory in 2008. Minimum energy performance standards are now in place.

Figure 3.1: Barriers to Energy Efficiency (EE) and Possible Policy Options

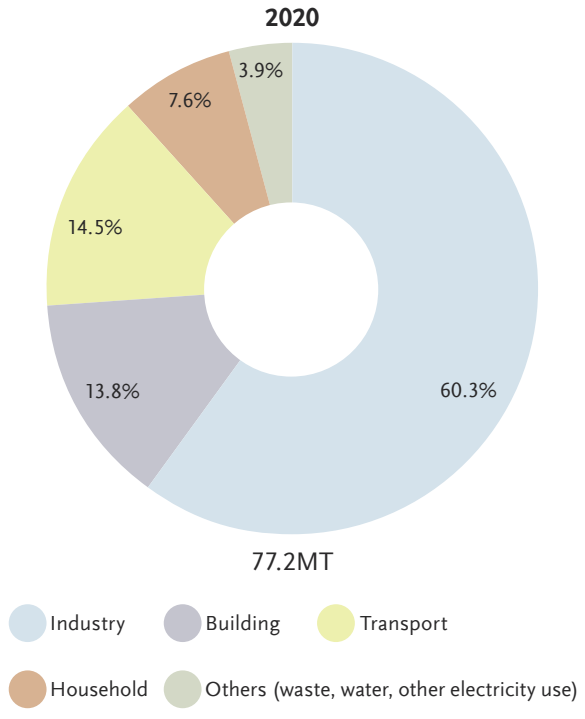
Barriers to EE		Policy Possibilities		
Limited capital	EE investments, even with net positive returns, compete with other investment opportunities.	Economy-wide carbon pricing	Fiscal tools	Levies, subsidies, rebates
				EE Financing Schemes
High upfront cost	EE investments may entail significant upfront cost.		Capability-building tools	Training programmes
				Educational campaigns
Lack of information	High search costs of time/ resources to research and implement EE solutions.			Voluntary information provision
Split incentives	Decision-maker does not reap benefits of investment.		Facilitative/ regulatory tools/ standards	Contracts structured to align incentives
				Mandatory information reporting/audits
Bounded rationality	Lack of understanding about EE; status quo bias for "tried and tested" products.			Mandatory EE standards

Projecting Singapore's Greenhouse Gas Emissions

Sectoral Contributions to 2020 Business-As-Usual (BAU) Level

The BAU level refers to a projection without policy intervention. It also refers to a "without measures", "baseline" or "reference" projection. Projecting from 2005, Singapore's BAU emissions are expected to reach 77.2 million tonnes (MT) in 2020[17] (see Figure 3.2).

Figure 3.2: Singapore's Projected 2020 BAU Emissions



Note: Figure refers to total greenhouse gas emissions. Greenhouse gases other than carbon dioxide (CO_2) are converted to their CO_2-equivalent. The sectoral contributions do not add up to 100% due to rounding of the respective percentages to one decimal place.

BAU growth (from 2005 to 2020) is influenced by the following factors:

a. *Power Generation*. Almost all of our energy is imported. We have already shifted most of our electricity generation away from fuel oil to natural gas, which is more efficient and cleaner. Due to limited potential in deploying renewable energy sources before 2020, Singapore's power generation will continue to be fossil fuel based. In our BAU projection for 2020, our fuel mix is assumed to be around 70% to 75% natural gas, with the rest primarily based on fuel oil. We will seek to further increase the share of natural gas in our fuel mix.

b. *Building*. Increasing demand for commercial space and more intensive use of space are likely to contribute to an increase in emissions from the building sector. Recognising this, we have implemented legislative measures and incentives to improve the energy efficiency of our buildings.

c. *Transport*. A growing population and economy will increase trips made for work, business and leisure. This in turn will drive up carbon emissions. Our mitigation efforts seek to invest more in public transport and encourage its greater use, as it is a more carbon efficient mode of transport. Emissions from domestic maritime transport are also expected to grow in line with expanding port activities. We are investing in efforts to increase energy efficiency in our aviation and maritime sectors as part of sustainable development.

[17] The projected economic growth is 3% to 5% per annum.

d. *Household*. Increases in population and household incomes are expected to increase demand for electrical appliances such as air-conditioners, televisions, lighting and refrigerators in our BAU emissions. We have put in place awareness programmes to inform households of ways to save energy and legislative measures to restrict the sale of energy inefficient appliances. We will consider more measures to influence purchasing and energy usage patterns.

e. *Industry*. Rapid urbanisation and the rise of the Asian middle class will shift global demand for products and services towards Asia. This will drive demand for expansion of petrochemicals and manufactured products from hubs such as Singapore. Our manufacturing sector is thus expected to continue to constitute a significant part in Singapore's economic mix, contributing to 20% to 25% of our economy.[18] It will account for the majority (60%) of our projected 2020 emissions. Given the earlier efforts to reclaim and prepare Jurong Island as an integrated efficient hub, global manufacturing companies have taken investment decisions to scale up their operations in Singapore in the coming years. Our refining and chemical industries are expected to contribute about half of Singapore's 2020 BAU emissions. We have put in place various schemes to facilitate the adoption of energy efficient technologies and processes in our manufacturing companies.

> "To achieve more emission reductions over time will require behavioural adjustments and changes to business processes. We will need to consider more stringent energy efficiency standards and legislation, along with measures taken by other countries."

DEPUTY PRIME MINISTER TEO CHEE HEAN DURING THE SINGAPORE PARLIAMENT COMMITTEE OF SUPPLY DEBATE, 1 MARCH 2012

[18] As a small country without natural resources and no hinterland, Singapore had to develop as an open economy with a strong export-oriented manufacturing base.

Refining and Chemicals Industries

The refining and chemicals industries are key components of Singapore's manufacturing mix, contributing around a quarter of our manufacturing output by value. By producing chemicals and fuels for a wide range of industries,[19] the cluster provides resilience to Singapore's manufacturing portfolio.[20]

Refining has a long history in Singapore. Energy trading started in the late 1890s—even before Singapore's independence—with operations by the Vacuum Oil Company and Shell on Pulau Bukom. Singapore's port, geographically positioned along the East-West trade routes, became an ideal hub for the supply of fuel to shipping and to meet regional needs. Shell set up Singapore's first oil refinery in 1961 and the Bukom facility has grown to be Shell's largest refinery globally. Other oil companies like Esso, Mobil, British Petroleum and Caltex subsequently established their presence in Singapore. By the mid-1970s, Singapore had become the third-largest export refining centre worldwide. As a major swing refinery centre, Singapore also caters to swings in demand in refined fuel products in the Asia Pacific.[21] In addition, our significant oil storage and trading infrastructure has made Singapore the Asian price discovery centre for oil products.[22]

Our refining and chemicals cluster is focused on moving up the value chain. This involves expanding the production of petrochemicals and specialty chemicals. These chemicals are used to manufacture plastic components used in a wide range of consumer products. Jurong Island, an amalgamation of seven offshore islands, was conceived in the 1980s to better integrate chemical cluster activity for greater efficiency. It is now among the world's largest 10 petrochemical hubs.[23] The close proximity of chemical companies on Jurong Island allows for overall system efficiency as products of one plant can be efficiently used as inputs in other plants. Steam (and electricity) demand can be supplied by co-generation plants.[24] This reduces the need for individual companies to produce their own steam supply, which reduces overall costs for companies and is also more energy efficient at the system level.

To provide a critical mass of feedstock for the industry so as to produce higher value-add chemicals, the Government had earlier indicated plans to increase the ethylene production capacity from 2 million tonnes per annum (mtpa) to 6–8mtpa in the long term. Two new crackers from ExxonMobil and Shell will bring the total ethylene production capacity to 4mtpa by 2012 and we expect a further pipeline of investments. Our strategy of moving up the value chain could also reduce the overall carbon intensity[25] of the chemical cluster in the long term (up to 25% by some estimates). The Singapore Government has been proactive in working with companies to improve levels of energy efficiency—conducting benchmarking studies and investing in research and development (R&D) efforts for efficiency improvements at the company and systemic levels. Moving forward, the Government will work with companies to aim for new investments to be best in class in terms of energy efficiency, and study further measures through a mix of incentives and legislation for existing plants.

[19] For example, our specialty chemical companies produce chemicals for our electronics and solar manufacturing sectors, e.g., electronic gases and encapsulants.
[20] The cluster has also been a source of resilient jobs.
[21] For example, due to weather and other contingencies such as unscheduled shutdowns of other regional refineries.
[22] Singapore has oil storage facilities amounting to nine million cubic metres. There are around 400 petroleum and petroleum product traders based in Singapore (Source: Singapore Department of Statistics).
[23] It is home to more than 95 leading petroleum, petrochemicals and specialty chemicals companies from all over the world and has attracted investments of over S$30 billion.
[24] One example is Power Seraya's 800MW co-generation plant which supplies steam and electricity to the Petrochemical Corporation of Singapore Complex and downstream companies on Jurong Island.
[25] Carbon emissions generated per GDP or economic value add.

Sectoral Measures to Reduce Emissions (Up to 2020)[26]

Mitigation Measures

Power Generation
Switch fuel mix away from fuel oil to natural gas for power generation

Encourage more solar test-bedding and research

Waste/Water
Incinerate sludge rather than dispose in landfills

Reduce plastics incineration

Households
Tighten Minimum Energy Performance Standards (MEPS) for household air-conditioners and refrigerators (2013)

Extend MEPS to lighting (2014) and more appliances

[26] Measures implemented after 2005 contribute to deviation from the 2020 business-as-usual (BAU) level. Work on the key mitigation thrusts and measures for the various sectors have started. The following sections outline these and further efforts in progress.

Capability development measure:
Energy Conservation Act for large energy users to develop energy efficiency improvement plans and take other measures (2013)

Buildings

Require Green Mark Certification for all new buildings

Require Green Mark Certification for existing buildings when retrofitted (2013)

Audit of building cooling systems every three years in new and existing buildings that have undergone retrofitting (2013)

Submit energy consumption and energy-related building data (2013)

Transport

Achieve 70:30 modal split between public and private transport

Implement Carbon Emissions-based Vehicle (CEV) Scheme to encourage purchase of low carbon emissions cars (2013)

Industry

Extend the Grant for Energy Efficient Technologies (GREET) scheme (2012)

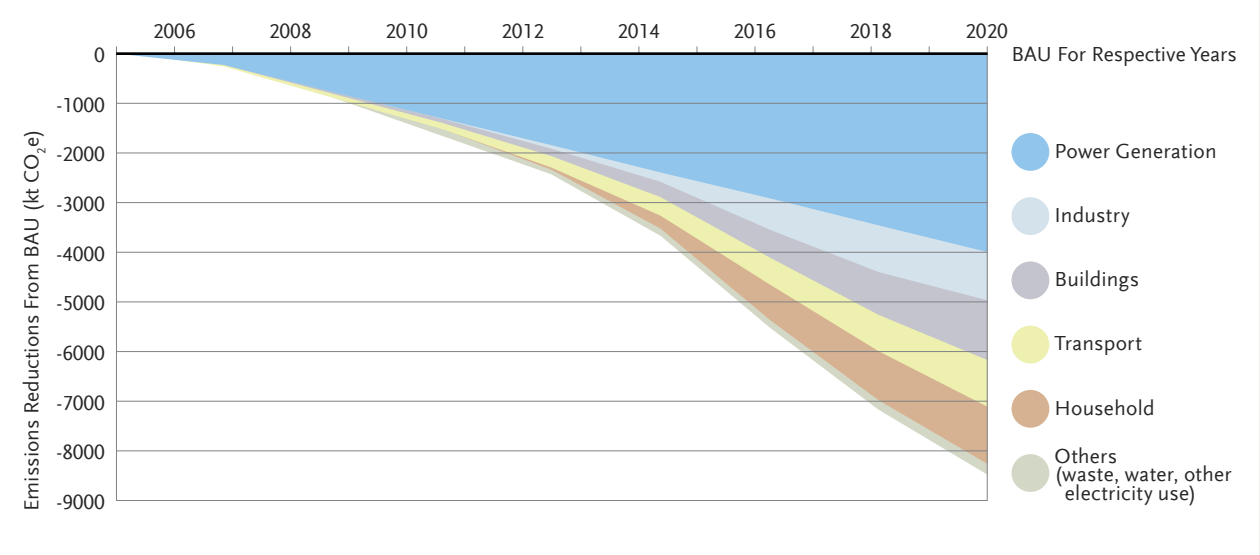
Develop and support energy efficiency financing pilot schemes (2012)

Encourage new co-generation plants in energy intensive sectors

To achieve Singapore's commitment to reduce our emissions by 7% to 11% below 2020 BAU levels, we are implementing mitigation measures in key sectors. Figure 3.3 reflects the estimated sectoral contributions.[27]

While the actual abatement for each sector may vary as measures are implemented, we expect that the overall target will be met. The power generation sector is expected to contribute close to half of the emissions reductions. The contributions by the industry and transport sectors are 11% to 13% each, 11% to 16% from the building sector, 10% to 16% from the households, and 2% to 3% from other sectors such as the water and waste sectors.

Figure 3.3: Sectoral Contributions to Emissions Reductions (from BAU)



[27] Sectoral contributions correspond to the situation where the efforts by households and businesses in response to the planned mitigation measures lead to an overall emission reduction of up to 11% from the 2020 BAU. Due to uncertainties in the response, the mitigation impact may be lowered to 7% from the 2020 BAU.

POWER GENERATION

Current perspectives

We have switched away from fuel oil to natural gas and the proportion of Singapore's electricity generated by natural gas has risen to about 80% today. Our carbon emissions from the power sector have dropped in tandem. Today, Singapore ranks among the countries with the highest percentage of use of natural gas for electricity generation.

Next steps

Singapore is **continuing with its fuel mix switch from fuel oil to natural gas**. At present, Singapore relies on natural gas piped from Malaysia and Indonesia. To ensure a resilient and more diverse supply of natural gas, the Singapore Government is building a liquefied natural gas (LNG) terminal that will allow us to import LNG from global gas markets. The terminal is expected to commence operations in the second quarter of 2013. This will allow Singapore to further increase the share of clean natural gas in our fuel mix in the future.

We are **exploring ways to increase our use of solar energy**. Among the renewable energy options, solar energy presents the best opportunities for Singapore. In our context, we expect electricity derived from solar energy to be cost-competitive vis-a-vis electricity derived from fossil fuels as prices of solar technologies decrease further. 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) has launched solar capability building schemes such as the Solar Capability Scheme (SCS) and Clean Energy Research Test-bedding (CERT). To understand how available solar technology can be adopted for local conditions, the Housing & Development Board (HDB) is conducting solar test beds in 30 HDB precincts over a five-year period. In addition, HDB is studying new business models for solar power. For example, under a solar leasing model being tested in Punggol, the town council leases solar photovoltaic (PV) systems from private companies, which will own, design, finance, install, operate and maintain the solar PV systems. The town council will then pay the company for the solar power consumed at a rate that is equal to or lower than the retail electricity tariff rate.

By the end of 2011, there were about four megawatt peak (MWp) of solar PV installations in Singapore, including projects at Resorts World Sentosa, Applied Materials' Changi North manufacturing plant, the Building and Construction Authority's (BCA) Zero Energy Building, and City Developments Limited's 7 & 9 Tampines Grande.

Singapore's first LNG terminal in Jurong Island, scheduled to be completed in 2013.

7 & 9 Tampines Grande, a commercial development, incorporates the use of Building Integrated Photovoltaic (BIPV) Panels (dark-coloured) on the building façade, as well as Photovoltaic Panels (dark-coloured) and Solar Thermal Panels (light-coloured) on the rooftops.

INDUSTRY

Current perspectives

A key concern in the industry sector is limited capital for investment in energy efficiency, especially for projects involving high upfront costs and longer payback periods. While energy efficiency investments have a positive rate of return, competing investments, such as plant expansions and other development projects, are often favoured. There may not be adequate information or understanding of available energy efficiency options, especially for smaller businesses which might not have the expertise or resources to determine more appropriate energy efficiency options for their needs.

Next steps

For the industry sector, the Government can facilitate energy efficient investments by **helping companies to identify commercially viable energy efficiency improvements and helping to defray upfront costs through co-funding**. At present, the Design for Efficiency Scheme (DfE) encourages investors to design energy and resource efficient facilities by co-funding up to 80% of the costs of engaging an energy consultant to conduct a design workshop. For existing facilities, the Energy Efficiency Improvement Assistance Scheme (EASe) co-funds the cost of engaging accredited energy services companies (ESCOs) to conduct energy audits and identify energy efficiency improvement measures. There are also grants and tax incentives for energy efficiency investments via the Grant for Energy Efficiency Technologies (GREET) and the Investment Allowance (IA) schemes. These schemes will focus on more energy-intensive industries. For example, incentives could facilitate the construction of co-generation plants for these sectors, which deliver higher efficiency compared to the separate production of electricity and steam.

We are also considering innovative ways to encourage energy efficiency improvements. These include the Energy Performance Contracting (EPC) model, in which a third party bears the upfront cost of energy efficiency investments and shares the expected energy savings over time with the consumer (businesses or households).

For example, the National Environment Agency (NEA) has been working with various government agencies and ESCOs to design and implement EPC for energy efficiency retrofits to public sector buildings. The EDB and BCA are also testing various models of energy efficiency financing. If found viable, the models could be implemented on a larger scale thereafter.

We are also supporting the development of expertise in Singapore that companies can tap on to drive energy efficiency improvements. To fully maximise their energy efficiency savings, firms must go beyond replacing individual pieces of equipment with more efficient alternatives, and explore ways to optimise their systems as a whole. Specialised skills are needed to accurately measure and benchmark current system performance, analyse data to identify opportunities, and design a holistic plan to realise system efficiency gains. Qualified energy efficiency experts are best placed to carry out these activities in a rigorous and systematic way. Current schemes such as the ESCO Accreditation Scheme and the Singapore Certified Energy Manager (SCEM) Programme will help grow such technical and professional capabilities in Singapore.

Energy Performance Contracting

Energy performance contracting is an arrangement under which an Energy Services Company (ESCO) is hired to examine the energy consumption of a building or facility, and then to identify and implement energy saving measures.

There are two broad models of performance contracting:

a. Shared savings model: The ESCO bears the cost of designing and implementing energy efficiency projects. The ESCO then recovers its costs and makes a profit by taking a fixed proportion of the money saved by the client company on energy bills, over a specified period of time.

b. Guaranteed savings model: The ESCO proposes a set of energy efficiency projects, and guarantees a specified level of energy cost savings as a result. The client company then pays for the energy efficiency investments. If the energy savings are less than the guaranteed level, the ESCO will make up the difference out of its own funds.

National Schemes for Building Energy Efficiency Capabilities

Energy Services Companies (ESCOs) Accreditation Scheme

Created to encourage the growth of ESCOs and to enhance their professionalism and quality of services, the Accreditation Scheme establishes a nationally recognised Register of Accredited ESCOs. This scheme is jointly administered by the NEA and BCA. ESCOs help companies identify and realise opportunities to improve energy efficiency. Their trained professionals play an important role in supporting companies that do not possess the internal capabilities to achieve these efficiency gains on their own.

Singapore Certified Energy Manager (SCEM) Programme

This was initiated to help engineering professionals develop the technical skills and competencies needed to lead energy services and management work in their organisations. The SCEM programme is jointly administered by the NEA and the Institution of Engineers Singapore. To encourage professionals to upgrade their skills, NEA offers a training grant which co-funds about 80% of the cost of the SCEM training course.

Participants attending an SCEM Programme.

While Government measures will play an important supporting role, industry leaders and senior management must ultimately devote attention to reduce energy consumption and carbon emissions. The experiences of many companies demonstrate that the right processes and personnel are crucial to reap significant energy and cost savings. These include ensuring prudent energy use, detecting and resolving energy wastage early, and monitoring the effectiveness of energy saving projects. They are often the result of consistent management attention in these areas.

The Energy Efficiency National Partnership

Launched by the National Environment Agency (NEA), Energy Market Authority (EMA), and Economic Development Board (EDB) on 29 April 2010, the industry-focused Energy Efficiency National Partnership (EENP) programme is a voluntary partnership programme that supports companies' energy efficiency efforts, thereby enhancing their long-term business competitiveness and reducing their carbon emissions. The EENP programme comprises three components: promotion of energy management systems; a learning network which provides opportunities for the industry to learn about energy efficiency ideas, technologies, practices, standards and case studies; and a national recognition scheme (known as the EENP Awards) that recognises the efforts and achievements of corporations and teams for excellent energy management practices and improving energy efficiency.

The Energy Conservation Act will come into force in 2013. It will mandate large users of energy to implement energy management practices.[28] The Act requires users in the industry and transport sectors which consume more than 15 gigawatt-hours equivalent (or 54 terajoules of energy) per year to appoint an energy manager, monitor and report their energy use and greenhouse gas emissions, and submit plans for energy efficiency improvement to the relevant agencies. Companies stand to benefit from improving their energy performance, thereby sharpening their competitiveness. By requiring the adoption of energy management practices through legislation, we can promote a coordinated approach to energy efficiency. The submission of plans will prompt companies to identify gaps that need to be addressed. Public agencies can review existing regulations and enhance capability development and financial assistance.

First Trigeneration plant in Singapore, owned by Pfizer Asia Pacific and developed by TPGS Green Energy.

[28] The Act will also consolidate energy efficiency related legislation that is currently found in different Acts. The Mandatory Energy Labelling Scheme and Minimum Energy Performance Standards for household appliances as well as the Fuel Economy Labelling Scheme for passenger cars and light goods vehicles under the Environmental Protection and Management Act will be consolidated under the Energy Conservation Act.

Energy efficiency improvements have been observed from the introduction of similar legislation in Japan, South Korea and Denmark.

The Singapore Government has also worked closely with companies, especially those in energy-intensive sectors, to uncover energy efficiency potential in companies through benchmarking studies, and to encourage the sharing of best practices on energy efficiency. There are also industry-led initiatives, such as the biomedical manufacturing energy workgroup, where energy managers of companies in the pharmaceutical sector under the co-leadership of Pfizer and GlaxoSmithKline share proven energy saving projects and practices. The group set a collective target of improving its energy intensity by an annual average of 6% among the companies. On average, they achieved an improvement of 7.4% in 2011 over the previous year.

Reducing Emissions in the Refining and Chemicals Industries

Recognising the carbon-intensive nature of the refining and chemicals industries, the Singapore Government has been proactive in working with these industries to achieve higher levels of energy efficiency. The close proximity of chemical plants on Jurong Island has enabled system-level energy efficiency options such as shared utilities and waste heat recovery. For example, a recent energy optimisation study conducted for the Petrochemical Corporation of Singapore complex on Jurong Island identified carbon abatement opportunities amounting to almost 10% of the complex's emissions, of which half were system-level reductions made possible by sharing utilities and greater integration.[29]

Jurong Island will also be a living lab for companies to develop and demonstrate innovative integrated solutions, such as tapping on waste heat to power productive processes. For example, the Cambridge Centre for Carbon Reduction in Chemical Technology—a collaboration between the University of Cambridge in the UK, the Nanyang Technological University and the National University of Singapore—is expected to open in early 2013 to develop low carbon solutions for the refining and chemicals industry. Jurong Island also provides a unique environment for companies to develop and test-bed carbon capture and utilisation technologies, due to the availability of concentrated carbon dioxide streams.[30]

[29] One recommendation from the benchmarking study is for waste heat from the process stream of one plant to be coupled with the generation of chilled water from an adjacent plant.

[30] Research is underway in Singapore on developing these technologies, under Singapore's A*STAR Thematic Strategic Research Programme. For example, one research project on carbon capture includes a pilot plant at the Institute of Chemical and Engineering Science to capture at least 200kg/day of carbon dioxide using an adsorption-based post combustion capture technology.

BUILDINGS

Current perspectives

Retrofitting buildings to improve their energy efficiency can yield positive returns. Energy cost savings usually offset the cost of retrofits in 5 to 7 years.

However, building owners also have competing uses for their capital, and are sometimes reluctant to undertake loans for energy efficiency projects, due to the impact on their balance sheets. In the case of new buildings, developers who intend to sell their buildings after construction may not invest heavily in energy efficiency features that benefit building owners and users but not them.

An Award-Winning Green Building Masterplan

The annual World Green Building Council Government Leadership Awards highlights world-leading government policies that maximise the opportunities for buildings to mitigate carbon emissions. For its Green Building Masterplan and efforts in steering the construction industry towards sustainable development in Singapore and the Asia Pacific, Singapore's BCA was conferred the inaugural Regional Leadership Award.

The Green Building Masterplan, first launched in 2006, focused on the greening of new buildings. The 2nd Green Building Masterplan, launched in 2009, gives greater emphasis to the greening of existing buildings. It sets out specific initiatives in six key strategic thrusts to achieve the national target of greening at least 80% of the buildings in Singapore by 2030. As of March 2012, there are more than 1,000 green building projects, translating to a gross floor area of about 30 million square metres, or 14% of the total gross floor area in Singapore.

2ND GREEN BUILDING MASTERPLAN

6 Strategic Thrusts

Strategic Thrust 1	Strategic Thrust 2	Strategic Thrust 3	Strategic Thrust 4	Strategic Thrust 5	Strategic Thrust 6
Public Sector Taking the Lead	**Spurring the Private Sector**	**Furthering the Development of Green Building Technology**	**Building Industry Capabilities through Training**	**Profiling Singapore and Raising Awareness**	**Imposing Minimum Standards**

Source: Building and Construction Authority.

Next steps

Developers and owners of **new building projects are required by the Building Control (Environmental Sustainability) Regulation to achieve minimum Green Mark standards**. This requires them to achieve 28% energy efficiency improvement from 2005 codes. The regulation applies to new buildings, and **existing buildings undergoing major retrofitting works**, with a gross floor area of 2,000m^2 or more. These standards benefit building owners as they reduce energy consumption while keeping compliance costs low. It does not cost much more to design and construct a Green Mark-compliant building than a normal one—the payback period is relatively short (see Figure 3.4) and the building can achieve between 20% and 40% energy savings over its lifetime. In addition, to enhance the environmental sustainability in key development areas such as the Jurong Lake District, Kallang Riverside and Paya Lebar Central, the new building projects are required to meet Green Mark Platinum or Gold^{Plus} standards.

BCA is using incentive schemes, such as the Green Mark Gross Floor Area (GM-GFA) scheme to encourage developers to achieve higher-tier Green Mark ratings of Green Mark Platinum and Gold^{Plus}; and the Green Mark Incentive Scheme for Design Prototype (GMIS-DP) for the design of breakthrough prototypes that can achieve ratings beyond Green Mark Platinum.[31]

Ocean Financial Centre was awarded the Green Mark Platinum Award in March 2008, recognising it as the eco-friendly office development of the future.

Figure 3.4: Range of Green Cost Premiums and Pay-Back Periods versus Level of Green Certification

BCA Green Mark Award Type	Green Cost Premium (%)	Payback Period (years)
Platinum	2% to 8%	2 yrs to 8 yrs
Gold^{Plus}	1% to 3%	2 yrs to 6 yrs
Gold	1% to 2%	2 yrs to 6 yrs
Certified	0.3% to 1%	2 yrs to 5 yrs

Source: Building and Construction Authority, Business Case for Green Buildings 2008.

[31] There are other initiatives. For instance, BCA's new Green Mark for Existing Residential Buildings Scheme recognises the eco-conscious efforts of town councils and managing agents. It also recognises the collective efforts of residents who participate actively in green initiatives within their estates. BCA has further gone "within buildings" to encourage end-users to green their premises. The BCA Green Mark schemes for Office Interior and Restaurants will support businesses in driving green initiatives within their premises. Going forward, BCA plans to develop Green Mark schemes for retail, supermarkets and data centres.

Green Mark Incentive Scheme—Design Prototype

The BCA Green Mark Scheme has driven the adoption of sustainable green building design and practices in the building sector. Recognised and supported by the industry, it has become the national yardstick for rating a building's environmental performance. It is also now a qualifying standard for determining eligibility and grant amounts under various green building-related incentive programmes. The revised BCA Green Mark criteria for new buildings (Version 4.0) places greater emphasis on passive design strategies to encourage more resource efficient designs.

The most high performance, energy-efficient buildings adopt an early collaborative design process, where the entire project team meets to understand each other's requirements and optimises their design using in-depth studies. To encourage such practices and push for even higher energy efficiency improvements, BCA introduced a S$5 million Green Mark Incentive Scheme–Design Prototype (GMIS-DP). This aims to encourage developers and building owners to strive for greater energy efficiency in buildings by placing more emphasis on the design stage. The scheme provides funding to engage Environmentally Sustainable Design consultants to conduct collaborative design workshops and assist in early simulation studies. It will benefit developers who are in the preliminary concept design phase of new buildings, and who target to surpass the standards of Green Mark Platinum, demonstrating energy savings of at least 40% better than the current base code.

Incentive Schemes for Existing Buildings

The BCA's S$100 million **Green Mark Incentive Scheme for Existing Buildings (GMIS-EB)** helps building owners offset part of the retrofitting costs to improve the energy efficiency of existing buildings.

The BCA's **Building Retrofit Energy Efficiency Financing (BREEF) pilot scheme** further encourages existing buildings owners with limited financial resources to go green, and financial institutions to offer financing for energy efficiency retrofits. Under this pilot scheme, BCA will share the risk of any loan default with participating financial institutions, who will provide loans to building owners and energy services companies to carry green retrofits.

There are plans to legislate new requirements for existing buildings to achieve minimum Green Mark standards as and when they are retrofitted. The Singapore Government will provide support to assist building owners in meeting mandatory minimum standards, and help jumpstart the greening of existing buildings in the private sector. The incentives will reduce the cost of retrofitting or design improvements. Energy services companies and professionals can also build up their capabilities in the process of greening our buildings.

Public buildings are expected to achieve efficiency improvements as well. With the Public Sector Taking the Lead in Environmental Sustainability Programme (PSTLES), all public sector buildings have to implement energy efficiency measures. New and existing public sector buildings undergoing major retrofitting works and with more than 5,000m^2 air-conditioned areas must achieve Green Mark Platinum ratings. All existing public sector buildings with more than 10,000m^2 air-conditioned areas are to achieve Green Mark Gold^{Plus} ratings by 2020. In addition, all large air-conditioned public sector office buildings, as well as Polytechnics and Institutes of Technical Education, will be subject to energy audits, while the energy usage of public sector infrastructure facilities will be audited thereafter. All Ministries are to set energy savings targets.

Singapore also contributes to regional capability building in climate change mitigation and sustainability, and shares our experiences with the wider region. For example, the BCA is working with the United Nations Environment Programme (UNEP) to promote and establish sustainable building policies and practices across Southeast Asia.

The Environment Building which houses the Ministry of Environment and Water Resources is a green building with features such as energy efficient lighting and occupancy sensors for meeting rooms.

BCA-UNEP Collaboration

The BCA is collaborating with the UNEP to promote and establish sustainable building policies and practices in the Southeast Asia region.

BCA's Centre for Sustainable Buildings in Singapore will assist countries in the region in developing tools and training to propagate sustainable solutions in the building sector.

BCA is also part of UNEP's Sustainable Buildings and Climate Initiative (UNEP-SBCI), a building sector partnership to promote the global adoption of sustainable buildings as a key strategy to address climate change impact.

Green Government Buildings

The Environment Building (ASEAN Energy Award 2007, BCA's Green Mark Platinum rating 2011) features an air-distribution system to control fresh air supply through the use of carbon dioxide sensors, sensors to automatically control lighting, occupancy sensors for meeting rooms, energy efficient lighting, and a modular cooling system for use after office hours.

The Treasury (Green Mark Gold rating 2009) features an energy-efficient chiller plant, pre-cooled air-handling units, motion sensors for most of its common toilets and use of NEWater for cooling towers.

The Ministry of Manpower Building (Green Mark Platinum rating 2011, ASEAN Energy Award 2011) features energy-efficient installations such as photocell sensors for perimeter lighting and energy regenerative units for lifts. The MOM facilities and project management team also retrofitted its chiller plant to achieve higher efficiency.

TRANSPORT

Current perspectives

Private cars contribute the largest share of land transport emissions (35%), followed by commercial vehicles, taxis, buses, Mass Rapid Transit (MRT)/Light Rapid Transit (LRT) and motorcycles (see Figure 3.5). Although public transport usage has been increasing in absolute terms, the public transport modal split—the percentage of morning peak hour commutes using public transport—has declined from 63% in 2004 to 59% in 2008. The carbon emissions from private cars have also risen as more people purchase models with higher engine capacities, which tend to emit more carbon emissions over time. This is in spite of a progressive registration and annual tax regime that penalises owners of larger cars.

In addition to bidding for the Certificate of Entitlement which confers the right to own a vehicle, a buyer of a new vehicle will also be taxed for vehicle purchase and ownership. Such taxes include the Additional Registration Fee (which can be up to 100% of the open market value of the vehicle), Excise Duty and Road Tax.

To help raise public awareness of fuel efficiency in cars and to encourage motor traders to bring in more fuel-efficient vehicles into Singapore, NEA introduced a Fuel Economy Labelling Scheme (FELS) in 2003 that was subsequently made mandatory in 2009. Under this scheme, motor traders provide buyers with fuel efficiency information to help them make more informed purchasing decisions.

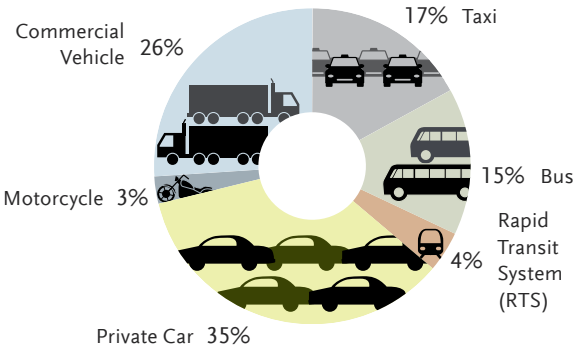
Next steps

Efforts will be stepped up to **increase the attractiveness of public transport and encourage its use**. Public transport is the most energy efficient mode of travel. A single-deck bus can transport about 80 passengers at any one time, while an average passenger car only carries up to 5 persons. Under the Land Transport Masterplan, Singapore targets to achieve a **70% public transport modal split by 2020, up from 59% in 2008.** The capacity of the existing rail network will be significantly increased from around 175km today to about 280km by the next decade so as to increase its reach and accessibility. The Government is also working with public transport operators to increase the capacity of the public bus fleet by about 20% from 2012 to 2016, through an injection of around 800 buses. This will help to raise existing bus service levels significantly and provide better connectivity for the bus network, and encourage greater use of public transport before the major rail projects and capacity enhancements come onstream in the medium term.

To increase the demand for low-emission cars and taxis, the Land Transport Authority (LTA) will **introduce the new Carbon Emissions-based Vehicle (CEV) Scheme in 2013** which will replace the existing Green Vehicle Rebate (GVR) for cars and taxis.

Under the CEV Scheme, all new and imported used cars, as well as taxis, will be banded into categories based on their CO_2/km performance data as shown in Table 3.1. Low-emission cars (bands A1–A4) will be given incentives—an Additional Registration Fee (ARF) rebate similar to the current GVR—while cars on the other end of the spectrum (bands C1–C4) will incur a penalty in the form of a registration surcharge. This will encourage more consumers to choose lower-emission car models.

Figure 3.5: Land Transport Carbon Emissions by Vehicle Mode (2005)



Source: Ministry of Transport.

The GVR is a technology-based scheme that provides rebates for the purchase of electric, hybrid and compressed natural gas (CNG) cars. In contrast, the CEV Scheme adopts a broader, technology-neutral "whole-of-vehicle" approach and uses the carbon emissions of various car/taxi models (i.e., CO_2 emission per kilometre (CO_2/km) performance measured under standardised test cycles) as its yardstick instead. This performance-based approach allows all aspects of improvement in the model's carbon efficiency to be taken into consideration.

Table 3.1: Structure of the CEV Scheme

Band	CO_2(g/km)	Rebate/Surcharge* for Cars
A1	0 to 100	$20,000 rebate
A2	101 to 120	$15,000 rebate
A3	121 to 140	$10,000 rebate
A4	141 to 160	$5,000 rebate
B	161 to 210	0
C1	211 to 230	$5,000 surcharge
C2	231 to 250	$10,000 surcharge
C3	251 to 270	$15,000 surcharge
C4	271 & above	$20,000 surcharge

*The rebate/surcharge quanta for taxis will be 50% higher than the quanta for cars.

Source: Ministry of Transport.

SBS Transit Hybrid Bus.

Double deck bicycle parking facilities at Pasir Ris MRT station.

Beyond using price signals, public information and education are also important. From the second half of 2012, LTA will administer FELS. Future FELS labels will contain additional information such as the vehicle model's carbon emissions in standard units, its relative performance compared to other models in the market, and its CEV Scheme banding. LTA will also set up a new online database so that consumers can easily compare the efficiency of different car models.

Electric transport solutions are possible in Singapore, given our well-developed R&D capabilities, robust electrical grid, advanced Information and Communication Technology (ICT) infrastructure and compact urban environment. A multi-agency Electric Vehicle Taskforce co-chaired by EMA and LTA is spearheading the Electric Vehicle (EV) test-bedding programme to assess the feasibility of EVs in Singapore. Vehicular tax exemption is provided as an incentive for test bed participants. Participants can choose from four models of EVs: the Daimler smart electric drive, Mitsubishi i-MiEV, Nissan Leaf and Renault Fluence Z.E.

LTA is also studying measures to reduce emissions from our bus and commercial vehicle fleet. For instance, LTA and public transport operators are collaborating on a trial of diesel hybrid buses. Diesel hybrid buses have been effective in other cities in reducing both carbon emissions and particulate matter emissions of the bus fleet. If the trial is successful, more of these diesel hybrid buses could be deployed in future.

Cycling has become increasingly popular in recent years. To facilitate cycling as an alternative mode of transport for short-distance trips, LTA is investing S$43 million to design and construct dedicated off-road cycling paths in seven HDB Towns[32] and Marina Bay. LTA is also providing better bicycle parking facilities near MRT stations to help cyclists transfer to public transport for longer distance travel. LTA has also worked with public transport operators to allow foldable bicycles on buses and trains during off-peak hours.

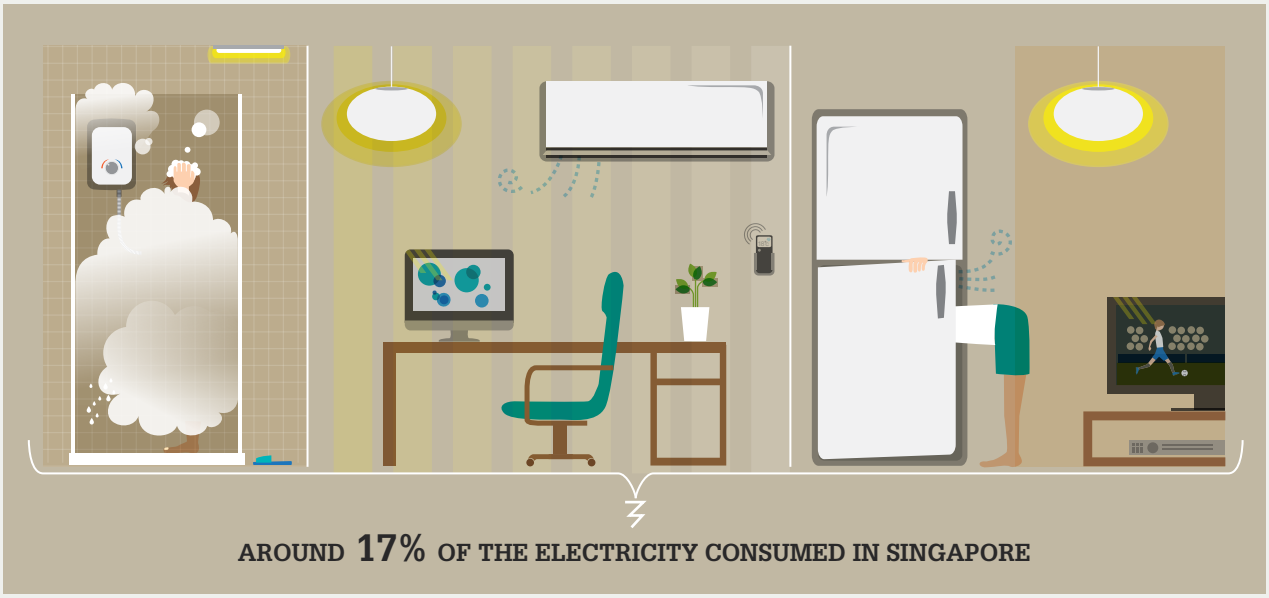
[32] The seven HDB towns are Tampines, Yishun, Sembawang, Pasir Ris, Taman Jurong, Bedok and Changi-Simei.

HOUSEHOLDS

Current perspectives

Households account for about one-sixth of the electricity consumed in Singapore. In a typical household, air-conditioning and refrigeration account for the lion's share of electricity consumption. This is followed by lighting, video equipment and water heating.

Households might not purchase energy-efficient appliances with higher upfront costs even though the lifecycle costs[33] may be lower. Electricity bills do not typically account for a large percentage of the average household's expenditure—households may correspondingly pay less attention to electricity costs compared to other expenditure items. Tenants whose rent includes fixed utility fees may not have the incentive to conserve electricity. If household appliances come pre-installed by developers or there are existing appliances purchased by landlords, households will not have the opportunity to choose energy efficient appliances.



AROUND **17%** OF THE ELECTRICITY CONSUMED IN SINGAPORE

[33] Lifecycle cost includes both the purchase price and total operating cost, which consists mainly of cost of electricity consumed over the useful lifecycle of the appliance.

Next steps

Feedback and public consultations indicate that households can achieve energy efficiency gains by adopting relatively simple habits and practices that will also yield cost savings. There is scope for better consumer awareness of the energy costs of operating various appliances, and greater efforts by retailers to import more energy efficient appliances for sale in Singapore.

To address these issues, the Government will improve the quality of information to facilitate more informed decisions by households when purchasing electrical appliances. Currently, the Mandatory Energy Labelling Scheme (MELS) allows consumers to compare the energy efficiency performance and calculate lifecycle costs of different models.

Singapore implemented the Minimum Energy Performance Standards (MEPS) in 2011, a supply-side measure which prohibits the sale of the most energy inefficient appliance models. **The MEPS scheme currently covers household refrigerators and air-conditioners, and will be extended to other household appliances in future**. The minimum efficiency standards for air-conditioners and refrigerators will be further tightened in 2013.

Energy efficiency labels on appliances.

MELS was implemented in 2008 for household air-conditioners and refrigerators. It was extended to clothes dryers in 2009.

The NEA also encourages energy efficiency and conservation through the 10% Energy Challenge. Energy saving tips have been promoted through media publicity, roadshows and community outreach. For wider outreach, information and tools to help households save energy at home is also made available on the E^2 Singapore website (www.e2singapore.gov.sg), which serves as a comprehensive source of information on energy efficiency matters in Singapore.

Minimum Energy Performance Standards in Singapore

Several countries such as Australia, New Zealand and Japan have implemented MEPS, which prescribe the minimum energy efficiency (or maximum allowable energy consumption) levels that a product must meet before it is allowed for sale. MEPS specify the energy performance but not the technology or design details of the product. MEPS, in conjunction with a well-developed energy labelling programme, has helped to reduce energy usage in Singapore.

Singapore's MEPS requirements are set based on the key considerations that it minimises lifecycle cost for consumers and does not overly constrain the availability of appliances and choice of models.

MEPS was introduced in September 2011 for household air-conditioners and refrigerators to help consumers avoid high energy consumption and energy costs of inefficient appliances. MEPS also encourages suppliers to bring in more energy efficient appliances that benefit consumers in terms of cost savings over the lifetime of the appliances. Since MEPS was legislated, almost 70% of air-conditioner models and 90% of refrigerator models on offer are 3- and 4-tick models (see Figures 3.6 and 3.7).

Market data shows that households, manufacturers and suppliers have responded positively to MELS and MEPS. The proportion of energy-efficient air-conditioners, refrigerators and clothes dryers sold has been steadily increasing over the years. In 2011, about 80% of purchases of household air-conditioners and 85% of refrigerators were from the top two highest efficiency categories of 3- and 4-tick models (see Figures 3.8 and 3.9).

In response to MELS and MEPS, manufacturers and suppliers brought in a wide variety of energy-efficient models and retired less efficient models. The share of energy-efficient refrigerator models (those with 3- or 4-ticks) registered with NEA increased from 46% in 2008 to 79% in 2011. Similarly, the share of energy efficient air-conditioner models increased from 30% in 2008 to 57% in 2011.

In order to lock in the efficiency gains that have been achieved by the collective efforts of consumers, manufacturers and suppliers, MEPS for household air-conditioners and refrigerators will be tightened in 2013.

MEPS will be extended to cover general lighting in 2014, as lighting is the third largest contributor to household electricity consumption after air-conditioners and refrigerators. Lighting accounts for about 10% of electricity consumption in a typical 4-room HDB household.

CONTINUED>

Figure 3.6: Air-Conditioner Sales

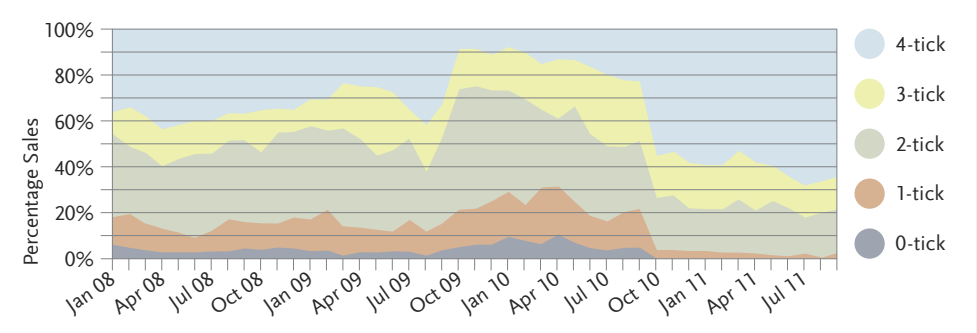


Figure 3.7: Refrigerator Sales

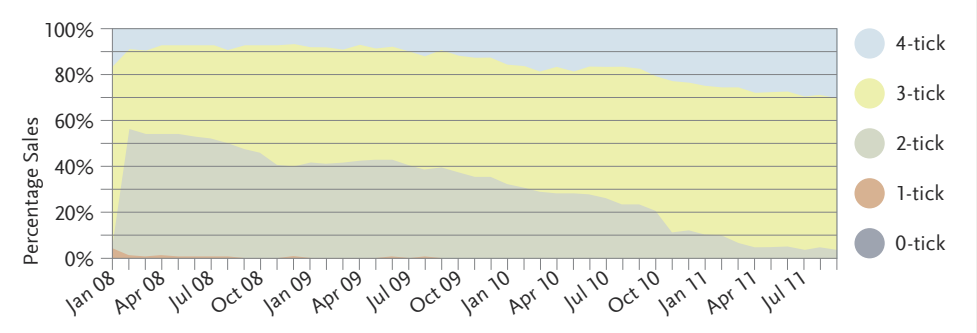


Figure 3.8: Number of Registered Air-Conditioner Models

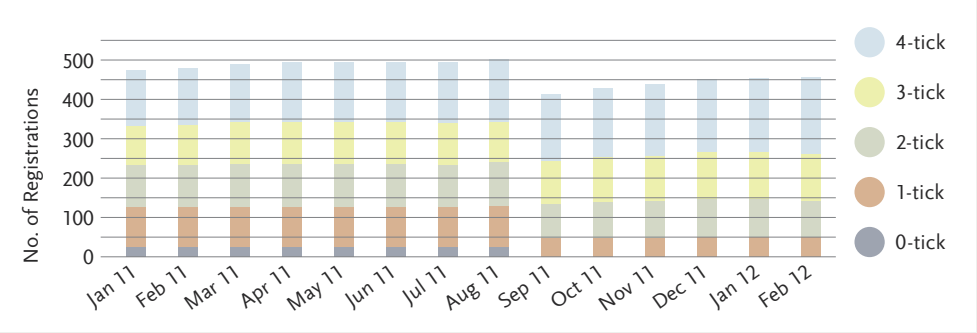
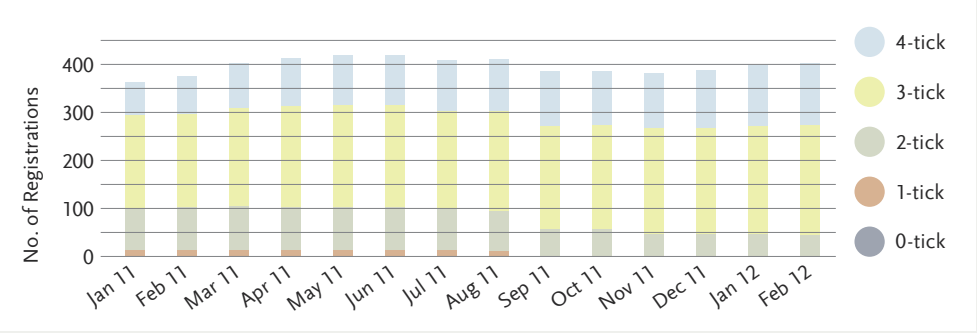


Figure 3.9: Number of Registered Refrigerator Models



WASTE AND WATER

We are acting to reduce emissions from waste. Our overall waste management strategy is to reduce waste through the 3Rs (reduce, reuse, recycle), and to incinerate the remaining waste in waste-to-energy plants. Incineration ash and non-burnable waste are then buried in landfill sites. Incineration is preferred over landfilling, since the direct burial of waste produces methane, a greenhouse gas. We intend to increase our recycling rate from 59% in 2011 to 70% by 2030, and we are looking into more ways to reduce emissions, such as **recycling more plastic waste instead of incinerating it**.

Singapore has also **reduced our direct methane emissions from wastewater sludge by incinerating the sludge**. Sumitomo Mitsui Banking Corporation and ECO-Special Waste Management (ECO-SWM) have collaborated to develop one of Southeast Asia's largest sewage sludge dehydration and incineration project in Singapore. The plant will result in the annual average reduction of an estimated 129,000 tonnes of carbon dioxide-equivalent, and is an emission reduction project registered with the UNFCCC to generate carbon credits in Singapore.

Desalinated water is one of Singapore's sources of water supply, meeting about 10% of the country's water needs. By 2060, PUB aims to expand our desalination capacity by almost 10 times to meet 30% of our long-term water needs. We have been investing in R&D to improve the energy efficiency of the desalination process. One project using electrochemical desalting aims to reduce energy usage to less than half of current membrane-based desalination methods. PUB is also experimenting with biomimicry, by studying natural desalination systems such as mangrove plants and marine fishes. This technology has the potential to reduce the required energy to less than a fifth of current methods.

Waste being prepared for incineration at the Keppel Seghers Tuas Waste-to-Energy plant. Besides diverting waste from landfills, incinerating waste also recovers heat energy that is used to produce and supply electricity to homes and factories.

Additional Measures to Enhance Carbon Reduction Efforts?

The measures outlined in this chapter are expected to reduce Singapore's emissions by 7% to 11% below the 2020 BAU level. However, the effectiveness of these policy measures will depend—to a large extent—on how businesses and consumers respond. The actual achieved figures for each sector may vary, but we expect that the overall target will be met.

In the event that additional emissions reductions are required, we will need stronger interventions in all sectors, including the possibility of introducing a carbon price. At the Singapore International Energy Week 2010, Prime Minister Lee Hsien Loong spoke about working through the market to deal with carbon emissions, and noted the need for a charge to induce changes to consumers' behaviour so that they would feel the cost of their consumption decisions and make the right choices. Pricing carbon could be done through a tax or cap-and-trade scheme. A carbon price will send the appropriate price signals to encourage changes in energy consumption and lower carbon emissions. This will also help Singaporeans and industries better adapt to the rising cost of energy.

A carbon price can also provide a market incentive for R&D in energy efficiency, and stimulate growth in green industries. It is important to invest in technology and R&D to find solutions to reduce our carbon emissions, as we explore feasible alternative energy solutions for Singapore. Just as our water constraints led us to develop NEWater,[34] climate change could provide the opportunities for Singapore to develop ourselves as a clean technology hub.

However, a carbon price will incur costs for businesses and households, with implications that will have to be worked through with different industries and groups. For instance, costs of production will rise more steeply for firms that use relatively energy-intensive inputs. Firms may also be concerned about their external competitiveness.

We have not reached a decision on carbon pricing and will need to consider the impact of any such scheme in Singapore, learning from the experiences of other countries.

[34] NEWater is high-grade reclaimed water produced from treated used water that is further purified using advanced membrane technologies and ultraviolet disinfection.

> We should also work through the market to deal with carbon emissions. Efficiency gains are important... But efficiency gains alone are not sufficient because of the rebound effect... Therefore, there is a need to impose a charge to induce consumers to change their behaviour so that they feel the cost of the consumption and they make the right choices. The best approach is to apply a carbon price, whether you have a tax on carbon or a cap and trade scheme. This depends on the institutional circumstances of the countries. But that you must price the carbon. That is a fact you cannot run away from.

PRIME MINISTER LEE HSIEN LOONG AT THE 2010 SINGAPORE ENERGY LECTURE, SINGAPORE INTERNATIONAL ENERGY WEEK, 1 NOVEMBER 2010

Looking Ahead

The International Energy Agency (IEA) assessed that energy efficiency policies and measures are the cheapest abatement option available and the most important source of abatement.[35] In Singapore's context, energy efficiency is also a key mitigation strategy. The people, private and public sectors need to work in close partnership to increase gains in energy efficiency.

There is strong public interest—businesses and consumers want more information on energy and fuel efficiency so they can make more informed decisions. At the same time, public awareness needs to be further translated into action. While there are immediate energy saving choices that households can make (such as choosing more efficient appliances and using public transport; using fans rather than air-conditioners; and using more efficient lighting) the challenge is to make the necessary adjustments and changes. Similarly, companies need to undertake measures to improve their energy efficiency including retrofitting equipment and buildings. The effectiveness of these actions will depend on the extent to which they are willing and able to incur some upfront costs. The Government, on its part, will enhance efforts to improve energy efficiency by public agencies. We will also provide the policy framework, put in place appropriate incentives and facilitate capability development efforts to improve energy efficiency levels in Singapore.

[35] This was demonstrated for the 450 Scenario, in which greenhouse gas emissions stabilise at 450 parts per million (ppm) of CO_2-equivalent, in line with an increase in global mean temperature of around 2°C above pre-industrial levels. Source: *World Energy Outlook 2011* © OECD/International Energy Agency 2011.

CHAPTER 4

Adapting to Climate Change: A More Resilient Singapore

Marina Barrage's nine crest gates act as a tidal barrier to keep out seawater so as to form Singapore's reservoir in the city and alleviate flooding in low-lying city areas.

Reverse osmosis membrane systems are used in the production of NEWater, an ultra-clean and high grade of reclaimed water. It will form an important component of Singapore's future water supply.

Even with the best efforts to limit the rise in global temperatures, countries should take adaptation measures to reduce the damaging impact of climate change and increase their resilience to potential future effects.

Singapore's annual mean surface temperature has risen from 26.8°C in 1948 to 27.6°C in 2011, consistent with overall global warming trends and an increase in Singapore's urban density. Analyses of rainfall data between 1980 and 2010 indicate that the daily rainfall totals and frequency of days with heavier rainfall—where hourly rainfall total exceeds 70mm—show an uptrend. Mean sea level has increased by about 3mm per year over the last 15 years.

Singapore's Approach on Adaptation

It is important for Singapore to make early preparations to adapt to climate change impact. Much of Singapore's land area of 710km^2 is less than 15m above sea level, with a generally flat coast. With a population of 5.2 million, Singapore is one of the most densely populated countries in the world.

Work has already started to enhance resilience against coastal erosion and inundation associated with rising sea levels coupled with weather variability. Water resources management is also a key priority. While many of the initiatives highlighted in this chapter were not conceived solely with climate change in mind, they are integral to Singapore's sustainable development efforts. At the same time, they provide a good foundation for our efforts to address the impact of climate change.

Protecting Our Coastline

We have made plans to protect our coasts and improve our drainage. For instance, in anticipation of rising sea levels in the future, the minimum reclamation levels for newly reclaimed land have been raised by 1m since late 2011, in addition to the previous level of 1.25m above the highest recorded tide level observed before 1991.

Addressing Flood Risks

An expert panel appointed by the Ministry of the Environment and Water Resources has reviewed the drainage design and flood protection measures that will be implemented in Singapore in the near to medium term, taking into consideration increasing weather variability and urbanisation. To increase our flood resilience, PUB, Singapore's national water agency, has revamped its approach to drainage and flood management to incorporate catchment-wide solutions, using advanced modelling tools, piloting a flood forecasting system and expanding the capacities of our drainage systems through 20 projects within five years. A risk-based approach will be taken as we continue to adapt our infrastructure to the longer-term effects of higher sea level and rainfall intensity.

Managing Our Water Resources

To ensure a sustainable water supply for Singapore's population and industry, PUB has built a robust and diversified water supply for Singapore through the Four National Taps, namely local catchment water, imported water, NEWater and desalinated water. In particular, NEWater and desalinated water are not dependent on rainfall and are thus more resilient against dry weather. These two non-conventional water sources were added to our water supply in 2002 and 2005 respectively, and together they meet up to 40% of our national water demand today. By 2060, PUB plans to triple the current NEWater capacity and ramp up desalination capacity so that NEWater and desalinated water meet up to 50% and 30% of our future water demand respectively.

Anticipating Singapore's Long-Term Vulnerability

In the 2007 Climate Change Study which examined the long-term effects of climate change on Singapore,[36] the mean sea level around Singapore could rise by up to 0.65m, and temperatures could increase by up to 4.2°C in 2100.

Key findings from Phase 1 of the study, completed in 2009, are summarised in Table 4.1.

These findings, based on the current state of knowledge on climate science and modelling, and peer reviewed by experts, are comparable to the findings in the Fourth Assessment Report (AR4) published in 2007 by the Intergovernmental Panel on Climate Change (IPCC). For rainfall, further studies are ongoing, as recommended by the peer review panel.

Table 4.1: Key Findings of the Singapore Climate Change Study

	Climate Change Projections (in 2100 relative to present)	IPCC AR4 Projections	Singapore Climate Change Study Findings
	Change in Average Temperature (˚C)	+1.7 to +4.4 (A1B Scenario, SE Asia)	+2.7 to + 4.2 (A1B Scenario)
	Change in Rainfall (%)	-2 to +15 (A1B Scenario, SE Asia)	Further studies needed—these are now ongoing
	Change in Mean Sea Level (m)	+0.18 to +0.59 (All IPCC Scenarios, Global)	+0.24 to +0.65 (3 IPCC Scenarios)

Source: Singapore's Second National Communications, November 2010.

Over time, these findings will be updated as climate science and models improve, and more information such as that arising from the Fifth Assessment Report by the IPCC becomes available.

As climate change affects various aspects of the environment and human development, the impact on areas such as our natural environment, public health, energy demand and urban infrastructure and other aspects as shown in Table 4.2 must also be addressed.

The ongoing work on each aspect involves bringing together expertise from multiple agencies. Phase 2 of the study is in progress and will investigate the impact of climate change on public health, urban temperature profile, energy consumption of buildings, and biodiversity.

Table 4.2: Impact of Climate Change on the Physical Environment

	Climate Change Effect	Examples of How the Physical Environment Could Be Affected
	Increase in temperature	Changes to biodiversity and greenery; implications for public health (e.g., from heat stress, mosquitoes); greater demand on energy infrastructure (for cooling)
	Change in rainfall (droughts) or intense storms	Reliability of water supplies; drainage and flooding issues; changes to geomorphology, biodiversity and greenery
	Sea level rise	Erosion and flooding of coastal areas
	Change in wind patterns	Public health (e.g., haze)

Source: Based on IPCC's AR4.

[36] The study was commissioned by an inter-agency technical group, led by the National Environment Agency.

Figure 4.1: Singapore's Adaptation Approach

Our Resilience Framework

Our understanding of climate change and its complex implications is constantly evolving. At the same time, some adaptation measures, which require time to implement, have to be taken early. The Singapore Government has therefore devised a resilience framework to guide our efforts towards safeguarding Singapore against projected climate change effects over the next 50 to 100 years as illustrated in Figure 4.1.

Adaptation plans will be designed for flexibility so that we can incorporate future learning. A multi-agency Resilience Working Group (RWG) under the auspices of the Inter-Ministerial Committee on Climate Change is studying measures to address our physical vulnerabilities to climate change. Studies currently being conducted include Phase 2 of the Climate Change Study (looking into the potential impact of climate change on public health, energy demand and biodiversity), and a detailed Risk Map Study to better identify specific coastal areas at risk of inundation.

Updates in the science of climate change and findings from our studies will advance our understanding of climate change risks, and help us develop adaptive measures to address these risks. The RWG will review existing measures and infrastructure that contribute towards climate resilience, and develop long-term adaptation plans for Singapore.

Enhancing Knowledge and Expertise in Climate Science and Adaptation for the Long Term

Further research is critical to enhance our understanding of climate science and adaptation options. Singapore lies within Southeast Asia, a region of high risk to climate change effects and other extreme weather events.

We are developing clusters in research areas to study the different aspects of climate change-related impact and vulnerabilities. As an understanding of regional and local climate is integral to building resilience, we are augmenting expertise in climate and weather science within the Meteorological Service Singapore and local research institutions, as well as forming partnerships with international experts.

Specialised and relevant research on climate change effects within Southeast Asia can help us identify the most appropriate adaptation measures for Singapore, and improve our resilience to climate change.

Role of Local Research Institutes

Singapore-based institutes are conducting applied research on climate change and coastal protection.

Work on local climate modelling is important because models and projections of climate change impact—based on regional or global data and assumptions—may not fully account for the specific variations in local climate and weather patterns.

Why Climate Change Effects Could Vary in Asia

According to Atmosphere-Ocean General Circulation Model[37] simulations, the effects of climate change in Asia are broadly consistent across the different models used.

However, some uncertainties remain. The models are limited by a lack of observational data from some areas of Southeast Asia. This affects the models' ability to assess projected changes in regional climatic means and extremes. Furthermore, different models represent monsoon processes in different ways. This is partly due to uncertainty over future regional monsoon and tropical cyclone behaviour, as climate scientists do not have full knowledge of future changes in ENSO (El Niño/La Niña-Southern Oscillation, a climate pattern that occurs across the tropical Pacific Ocean roughly every five years).

As a result of these uncertainties, it is difficult to obtain quantitative estimates of projected rainfall changes. It is likely that some local climate changes will vary significantly from overall regional trends, due to the region's very complex topography and marine influences.

[37] Atmosphere-Ocean General Circulation Models are the primary tool used for understanding of past climate variations, and for future projections globally and regionally.

Centre for Climate Research Singapore

The Meteorological Service Singapore (MSS) has established a Centre for Climate Research Singapore (CCRS) to build up in-house capability in climate science and climate modelling.

Guided by an International Scientific Advisory Panel on Climate Science, the Centre will also tap on relevant experts and institutions through a Climate Science Experts Network to coordinate and steer climate-related research in Singapore. The Experts Network will leverage a range of interdisciplinary expertise in local academia to complement that of the CCRS. This will build up Singapore's expertise in climate science, to help augment national preparedness for climate change and inform policy decisions.

Minister for the Environment and Water Resources Dr Vivian Balakrishnan, with Senior Minister of State Ms Grace Fu at the launch of the book "The Weather and Climate of Singapore", at the Upper Air Observatory of the MSS.

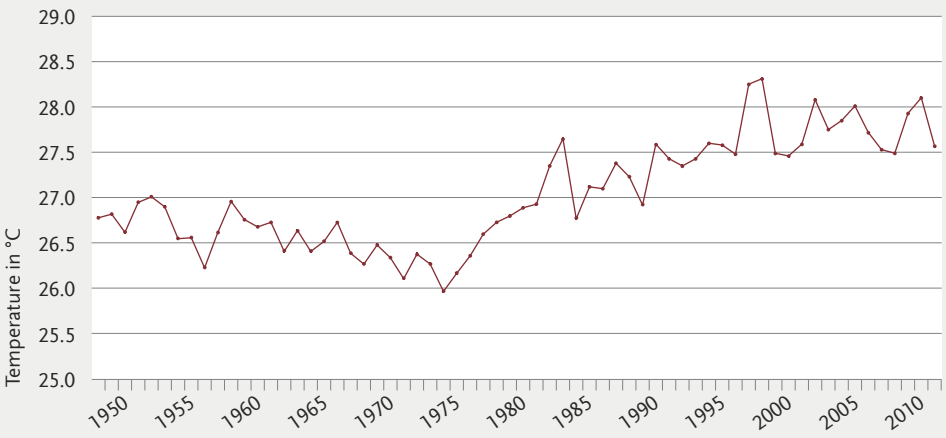
Facts and Figures on Singapore's Historical Weather Trends

"Weather" is the mix of atmospheric events involving temperature, rainfall, humidity etc. occurring daily while "climate" generally refers to the average weather pattern over many years. On a day-to-day basis, the patterns may have large deviations from the average.

In Singapore, it has been observed that the annual mean surface temperature has risen from 26.8°C in 1948 to 27.6°C in 2011. This would be consistent with overall global warming trends and an increase in Singapore's urban density (see Figure 4.2).

Trends in annual rainfall may at first appear less striking (see Figure 4.3). However, analyses of daily rainfall totals and frequency of days with heavier rainfall between 1980 and 2010 show a statistically significant uptrend (see Figure 4.4).

Figure 4.2: Annual Mean Surface Temperature (°C)



CONTINUED>

Figure 4.3: Annual Rainfall (mm)

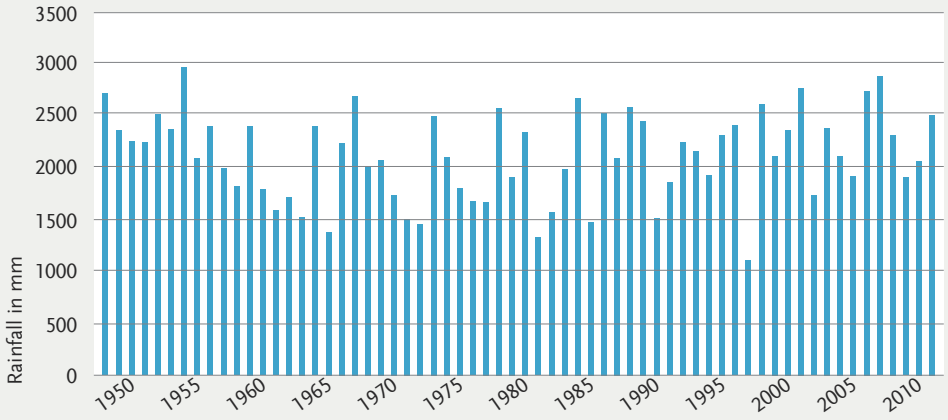
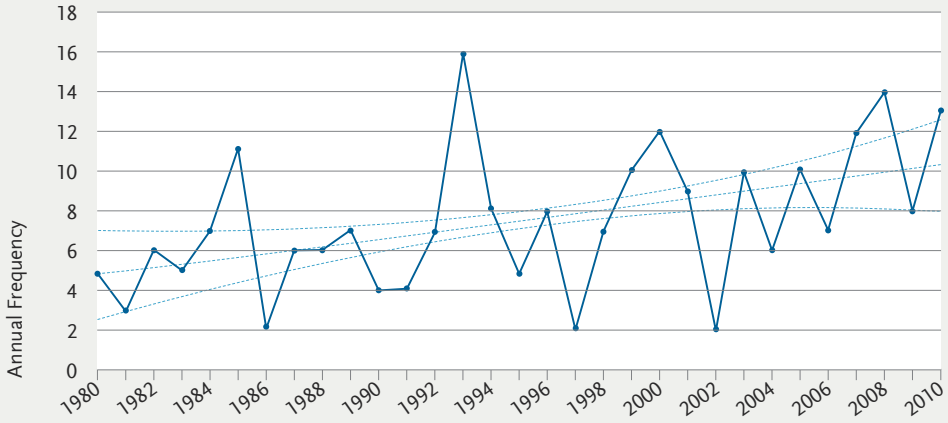


Figure 4.4: Annual Frequency of Days with Heavier Rainfall



Note: The trend is indicated by the blue line and the 95% confidence interval.
Source: Meteorological Service Singapore.

Historical trends are only one input to understanding the future climate. Given the well-known complexity of rainfall in the tropics, specialised climate models are required to help build a picture of the future. Such models were used for the National Environment Agency's (NEA) 2007 Climate Change Study and will be an important part of ongoing and future studies.

To facilitate applied research work, the National University of Singapore (NUS) and Nanyang Technological University (NTU) have set up several research institutes and centres.

- The Singapore-Delft Water Alliance (SDWA)
- Tropical Marine Science Institute (TMSI)
- Earth Observatory of Singapore (EOS)
- Institute of Catastrophe Risk Management (ICRM)
- Maritime Research Centre (MRC)
- NTU-JTC Industrial Infrastructure Innovation (NTU-JTC I^3) Centre

Apart from working with government agencies, the institutes also collaborate with their counterparts overseas, improving our access to global research expertise in the field.

In addition, the Institute of High Performance Computing (IHPC) of the Agency of Science, Technology and Research (A*STAR) uses computational modelling, simulation and visualisation methodologies and tools to conduct research in various scientific fields including fluid dynamics, engineering mechanics, and materials science and engineering. IHPC's work on climate resilience includes modelling the spread of infectious diseases, urban air flow and climatic data management.

Research Institutes Working on Domains Relevant to Climate Resilience

Singapore-Delft Water Alliance (SDWA)
SDWA improves our understanding of the water cycle through environmental sensing, intelligent data processing and modelling. This includes capability on real time forecasting and warning, such as in the simulation and analysis of extreme events, to develop decision support systems. With the Dutch research institute Deltares, NUS has recently established a new collaboration arising from the SDWA initiative to form NUSDeltares to pursue high impact water research and specialist consultancy services in Singapore and Southeast Asia.

Tropical Marine Science Institute (TMSI)
TMSI is a centre of excellence for research, development and consultancy in tropical marine science as well as environmental science. With its multidisciplinary research laboratories and active international links, it handles projects relevant to Physical Oceanography, Acoustics, Marine Biology, Marine Mammals, Biofuels, Water Resources and Climate Change. TMSI was involved in Phase 1 of the Climate Change Study, and is helping with the current Risk Map Study for Singapore.

CONTINUED>

Earth Observatory of Singapore (EOS)
Set up in NTU to deepen knowledge on natural catastrophes and climate change science, EOS's research seeks better predictions of regional consequences that can be expected from global climate change, by taking into account global climate drivers active in this tropical region, such as the Western Pacific Warm Pool and the Indian Ocean Dipole. A forthcoming study will look at how changes to the sea surface temperature, saltiness and water circulation affected the Southeast Asian monsoon in the past.

Piecing together this history is essential to predict how the climate in this region may change in the future. In Singapore's context, such knowledge could also be used to plan for future drainage systems to cope with climate change.

Institute of Catastrophe Risk Management (ICRM)
The ICRM is the first multidisciplinary risk management research institute of its kind in Asia and amongst a handful of such centres in the world. NTU's Risk Research Agenda is driven by the principle that catastrophic risk affects the functioning and effectiveness of society and businesses. Understanding, communicating and managing catastrophic risk requires comprehensive methodologies for risk quantification (monetary, social and human). The Institute's focus is on catastrophe-triggered insurance/reinsurance risks, sovereign risk, societal risk and some non-traditional risks.

Maritime Research Centre (MRC)
MPA and NTU have jointly established the MRC as a national and regional centre for maritime research activities in hydrodynamics, marine and offshore engineering, shipping business and logistics. The MRC coordinates maritime research and development (R&D) efforts across local and international organisations. Its work includes research on beach stabilisation, and the role of mangroves in protecting mudflats from erosion.

NTU-JTC Industrial Infrastructure Innovation (NTU-JTC I^3) Centre
Seeking to promote growth and development of economically viable and sustainable industrial infrastructure solutions in Singapore, the NTU-JTC I^3 Centre covers fields such as land reclamation and specialised marine infrastructure, energy and water recycling, underground infrastructure design and construction, and novel construction methods and systems. The Centre's research thrusts are in four areas, namely reclamation and marine infrastructure, sustainable infrastructure, underground infrastructure, and infrastructure systems and materials. It also aims to build new capabilities and to scale up technical leadership competencies in the area of industrial infrastructure development.

Preparing Singapore: Areas of Work in Progress

The Singapore Government is bridging gaps in knowledge and building capabilities on our adaptation options, and shaping resilient studies in areas that may be affected by climate change. In addition, there are ongoing studies in domains such as food supply and security, which are not exclusively linked to climate change. Such work will be considered when implementing adaptation measures to address identified risks.

Coastal Protection

As a low-lying island, sea level rise poses the most immediate threat to Singapore. Much of Singapore lies within 15m above the mean sea level; and the ground level of about 30% of Singapore is less than 5m above the mean sea level. Currently, about 70% to 80% of Singapore's coastal areas have hard walls or stone embankments, which help protect against coastal erosion. The rest are natural areas such as beaches and mangroves.

Since 1991, all new land reclamation projects have to be built to at least 1.25m above the highest recorded tide level. In 2011, the minimum land reclamation level for new projects was raised by an additional 1m to ensure that the new reclaimed land is safeguarded against long-term sea level rise.

Coastal protection involves a broad range of related fields such as coastal engineering, wave dynamics, coastal morphology, and hydrodynamics. Several public agencies, including the Building and Construction Authority (BCA), Housing & Development Board (HDB) and JTC Corporation (JTC) have developed capabilities in these areas, and have been heavily involved in coastal engineering and coastal protection works.

BCA has set up a Coastal and Project Management Department to focus on coastal protection and adaptation issues.

Next Steps

BCA has commissioned a Risk Map Study to better identify the specific coastal areas at risk of inundation and the potential damage associated. The study, expected to be completed by end 2013, covers the whole of Singapore's coastline and involves several site topographical surveys. The results will help in the development of coastal protection strategies against probable inundation by the sea.

There is also growing interest in "soft" coastal protection practices including the use of plants (such as mangroves and sea grasses) for coastal protection, as well as beach and dune nourishment. Research and collaboration with local institutions will be embarked upon to advance these areas and other approaches which are relatively new to Singapore.

Minimum platform levels for new reclamation projects were increased to cope with potential rising sea levels.

Mangrove Restoration in Singapore

Mangroves along the north-eastern coast of the island of Pulau Tekong were being scoured as a result of coastline erosion. Using a combination of rocks, mangrove plants and biodegradable rings, a multidisciplinary team led by the National Parks Board (NParks) achieved several outcomes:

- coastal protection;
- restoration of mangrove habitat; and
- test-bedding of environmentally sustainable soft engineering solutions.

The project brought together experts from both the private and public sectors, including biologists, coastal engineers, modellers and horticulturists.

Natural ecosystems help to moderate and buffer effects of extreme weather conditions. Mangroves, for example, help stabilise and protect coasts against erosion.

Water Resources and Drainage

An increase in rainfall intensity and weather variability could present significant challenges for the management of our water resources. Periods of drought may affect the reliability of Singapore's water supply, while sudden episodes of intense rainfall could overwhelm our drainage system and lead to flash floods. With climate change, these extreme weather events could increase in both frequency and intensity.

PUB has developed a diversified and robust water supply through the Four National Taps (local catchment water, imported water from neighbouring Malaysia, NEWater and desalinated water) to ensure a sustainable water supply for Singapore's population and industries (see Figure 4.5).

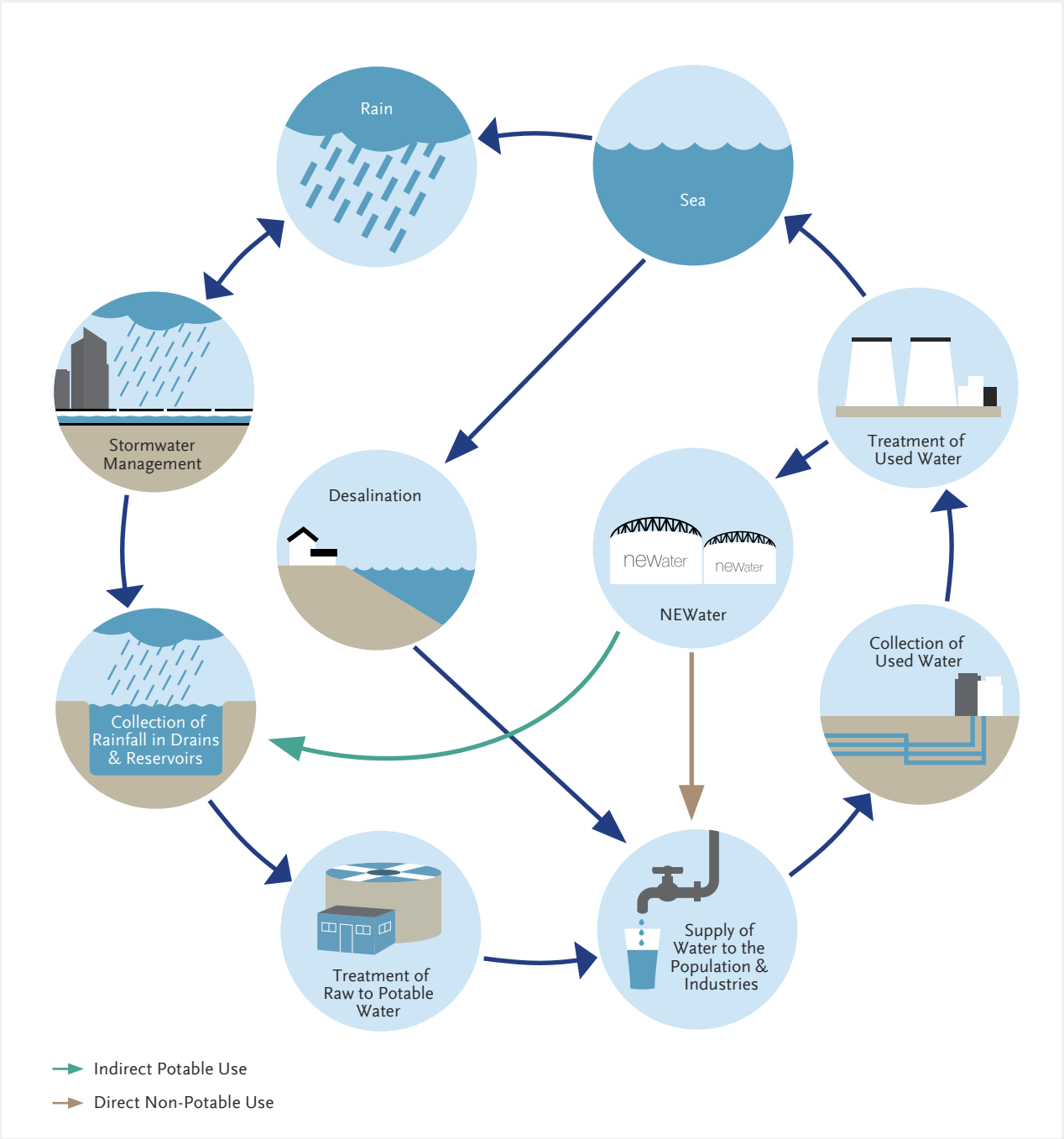
NEWater, Singapore's Third National Tap

NEWater is treated used water that has undergone a stringent purification and treatment process using advanced dual-membrane (microfiltration and reverse osmosis) and ultraviolet technologies. It was introduced by PUB in 2002 to increase water supply from non-conventional sources for non-potable use. Because of its high-grade quality, NEWater can be used for wafer fabrication processes, non-potable applications in manufacturing processes as well as air-conditioning cooling towers in commercial buildings, freeing up a large amount of potable drinking water for domestic consumption.

A percentage of NEWater is also blended with raw water in the reservoir. The raw water from the reservoir then goes through treatment at the waterworks before it is supplied to consumers as tap water.

NEWater and desalinated water are not dependent on rainfall and can be used to supplement water from local reservoirs in an extended dry spell. NEWater and desalinated water will meet about two-thirds of Singapore's water demand by 2020. The capacity for these two sources of water will be further increased to meet up to 80% of our water demand by 2060.

Figure 4.5: Water Loop Illustrating Singapore's Water Management



Energy Use in Water Reclamation and Desalination

Although much has been done to improve the drought resilience of our water supply system, risks of dry spells and extreme weather conditions remain. One implication of using NEWater production and desalination to augment our resilience is that they require a relatively higher amount of energy compared to treating local catchment water sources. While PUB will continue to invest in R&D to seek more energy-efficient water treatment processes, the solutions take time to develop and mature.

For example, through a research grant from the Singapore Government in 2008, Siemens Water Technology has developed low-energy desalting technology that is able to produce potable water while consuming approximately half the energy required by conventional reverse osmosis desalting processes. Siemens is now working with PUB to test-bed the technology under actual plant conditions. The Singapore Government is working with academia and the industry on other areas of research such as energy self-sufficient technologies for wastewater treatment and improvements in water recovery rate from membrane bioreactor treatment processes.

Water conservation is an important complementary strategy to ensure Singapore's long-term water sustainability. Through public outreach and other measures, the daily per capita domestic water consumption has dropped from 165 litres in 2003 to 153 litres in 2011. Our long-term target, set out in the Sustainable Singapore Blueprint, is 147 litres in 2020.

The development of drainage infrastructure in Singapore, amounting to S$2 billion over the last 30 years, has reduced flood prone areas from about 3,200ha in the 1970s to about 49ha as at January 2012. With PUB's ongoing drainage improvement works, these flood prone areas will be progressively reduced over time.

Continual drainage improvement works, which include expansion of drains and canals, are carried out to ensure the adequacy of Singapore's drainage system.

Minimum crest levels are required for entrances to underground facilities such as Mass Rapid Transit (MRT) stations.

Next Steps

PUB announced in January 2012 a multi-pronged plan to strengthen Singapore's flood resilience. The new plan includes higher drainage design standards, more holistic solutions that consider the entire drainage system, better modelling capabilities and stakeholder engagement to improve overall preparedness.

Recognising that expanding drainage will not be sufficient, especially for areas that are more developed and have site constraints, PUB will go beyond conventional solutions (e.g., expanding drains and canals) to developing solutions at 'source' (e.g., green roofs and porous pavements) to better manage stormwater run-off, and at 'receptors' (e.g., raised platform, crest levels and flood barriers) to protect buildings at the local level.

PUB plans to carry out 20 drainage improvement projects over the next five years to enhance flood protection. It will also work closely with public sector agencies, developers and professional bodies to introduce measures to manage run-off at source (where rain falls) and receptors (where rainwater flows to) to protect buildings and facilities.

Biodiversity and Greenery

Climate change will affect the diversity of plants and animals, and this will alter our ecosystem and natural processes such as soil formation, nutrient storage, and pollution absorption.

If coastal vegetation is adversely affected, there could be changes in the position and rate of erosion along the shore. There could also be changes in the mitigating effects of coastal vegetation on flooding or tidal surges. Likewise, increased rainfall as a result of climate change can affect slope stability, and adversely affect the vegetation which normally holds soil in place on slopes.

Singapore's remarkable urban biodiversity and extensive greenery are what makes us a "City in a Garden". Our green spaces are necessary. Extensive roadside tree planting has contributed to the relatively cooler temperatures in places like Orchard Road in the heart of the city. Over 300 parks and the network of green park connectors provide relief from the hot urban tropical climate. Water demand will also be lowered whenever temperatures can be kept lower.

Next Steps

NParks will investigate the potential impact of climate change on biodiversity and greenery in greater detail. Working with other agencies, it will locate and stabilise potentially vulnerable slopes.

To keep our city green, tree management and maintenance will also be enhanced. The current health checks on our trees will be conducted more thoroughly and frequently, while more suitable species which are less vulnerable to storms and strong winds will be planted along our streets.

The Keruing (Dipterocarpus caudatus ssp. penangianus) tree in the primary rainforest of the Bukit Timah Nature Reserve in Singapore, a microcosm of the biodiversity in the region.

Climate Change and Biodiversity

A mean temperature increase of 1.5°C to 2.5°C could place a significant proportion of terrestrial species in Singapore at risk.

With a rise in temperature, the impact on plants and animals will depend on the change in rainfall. Warmer and drier conditions are likely to stress trees, affect their growth and possibly shorten their lifespans. While such conditions might encourage more profuse flowering by some roadside ornamental plants, they may also encourage the spread of weeds.

The effects of warmer and wetter conditions are less easy to predict. Trees may grow more quickly, but this might also shorten their lifespans. Many rare animals in Singapore—such as the Banded Leaf Monkey, the Leopard Cat and other rare mammals—may require intensified conservation. Species with the smallest habitat ranges are likely to be the most at risk, including Singapore's three endemic freshwater crabs.

To counter the effects of changes in temperature and rainfall, NParks has started work to conserve biodiversity. EcoLink@BKE, Southeast Asia's first ecological corridor across the Bukit Timah Expressway and linking up of the Bukit Timah Nature Reserve and Central Catchment Nature Reserve, is slated to be completed in 2013. This will increase the territory size of native animals and improve dispersal of plant species, enhancing resilience of plants and animals to pressures linked to climate change.

Sea level rise will be a challenge for mangroves, which cannot retreat inland. The Sungei Buloh and Mandai mudflats, for instance, are a key feeding ground for over 1,500 birds which migrate annually along the East Asian-Australasian Flyway.

Corals, which require sunlight, may not be able to grow upwards quickly enough to keep pace with rising sea levels. In addition, a 1°C to 2°C rise in sea water temperatures will lead to coral bleaching, which occurred in 1998 and 2006, and killed at least 16% of coral reefs worldwide.

Public Health

Singapore is situated in a region where vector-borne diseases, such as dengue, are endemic. There may be a link between rising temperatures and the incidence of such diseases. For instance, more dengue cases are observed during the warmer periods of the year.

To minimise dengue incidence through suppressing the mosquito vector population, NEA has put in place a nation-wide integrated programme, which entails mosquito, virus and human surveillance as well as public education and participation, law enforcement and research.

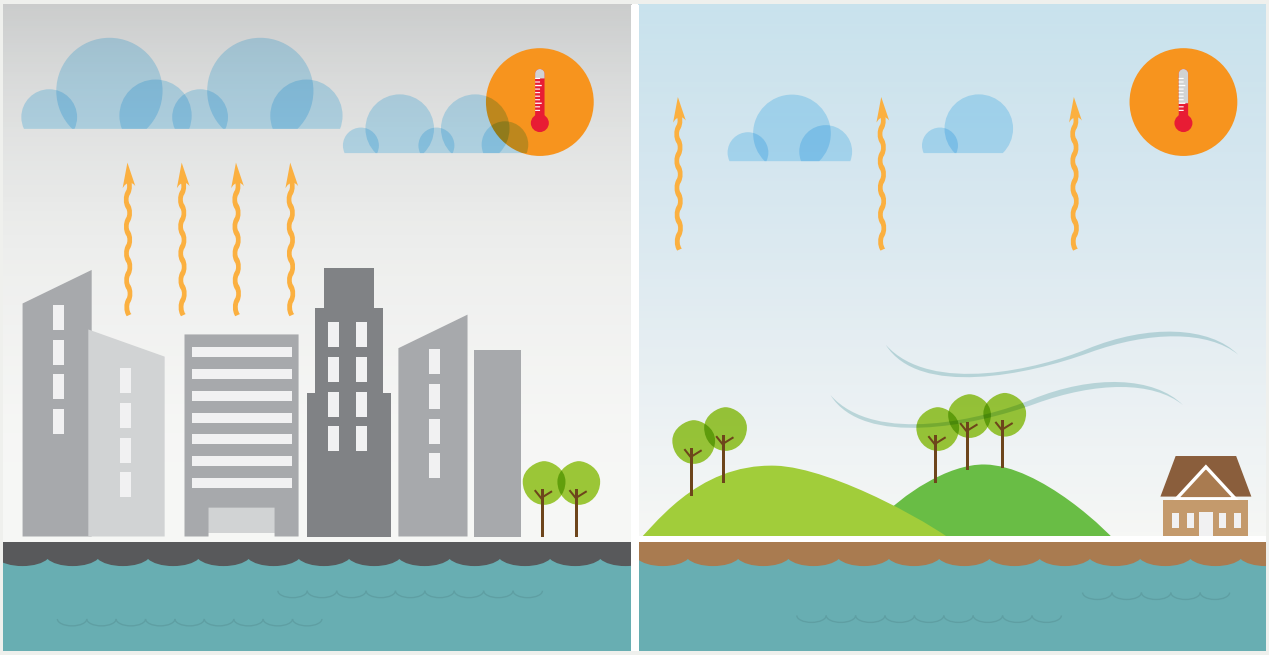
Frequent and severe episodes of warm weather could also lead to increased occurrences of heat stress and discomfort, particularly among the elderly and the sick.

Next steps

NEA is collaborating with the Ministry of Health to study the relationship between climatic factors—such as temperature, humidity and rainfall—and public health risks such as dengue fever, and heat disorders and respiratory diseases. The study will also look into forecasting the risk of disease transmission in different scenarios.

NEA's Environmental Health Institute (EHI), a World Health Organisation Collaborating Centre for the Reference and Research of Arbovirus and their Associated Vectors, will leverage its research capability in vector-borne diseases to support efforts to strengthen Singapore's public health resilience to climate change.

A researcher at the EHI under NEA, investigating the behaviour of the Aedes mosquito and dengue virus so as to formulate appropriate preventive and control strategies.



An urban heat island is a metropolitan area which is significantly warmer than its surrounding rural areas. The temperature difference is usually higher at night than during the day, and is most apparent when winds are weak.

Energy Demand and Urban Infrastructure

While climate change may contribute to rising temperatures, Singapore could also experience warmer temperatures as a result of the urban heat island effect.

Higher annual temperatures can lead to heat stress, as well as greater use of air-conditioning, increasing Singapore's energy demands. While we have sufficient generation capacity to meet such an increase, we have to be mindful of increasing energy use, which will also result in higher domestic carbon emissions.

Another effect of climate change that may affect urban infrastructure is wind speeds. Phase 1 of the Climate Change Study found that future wind speeds will not be higher than the current speeds that our buildings are designed to withstand. Therefore, the structural integrity of buildings is unlikely to be affected.

The Urban Heat Island Effect

Urban areas tend to be warmer than rural or green areas, largely due to the replacement of natural land cover with pavement, buildings and other infrastructure that tend to retain or produce heat.

Next steps

Optimal land use planning and urban design can help create cooler and more comfortable environments for people to enjoy, counteracting some of the effects of rising temperatures.

The Energy Market Authority and Building and Construction Authority are studying Singapore's urban temperature profile and the energy consumption of our buildings to understand how temperature increase and wind changes will affect us.

The Urban Redevelopment Authority is working with HDB, NUS and IHPC of A*STAR on a Climatic Mapping Study to understand how the built environment and urban greenery could affect micro-climatic conditions such as air flow and temperature. The island-wide study will also identify hot spots and cooler areas in Singapore, and provide recommendations on the planning and design of public spaces and buildings, such as increasing the amount of greenery and modifying building layouts.

Looking Ahead

The Singapore Government takes a long-term approach to infrastructural planning. Work has started to enhance Singapore's resilience to climate change.

We are also developing capabilities within Singapore on climate science and adaptation measures, in partnership with research institutions both locally and abroad. As climate science evolves, we will need to refine and reassess our key areas of vulnerability, and the most appropriate adaptation strategies. Such plans take time to implement, and will need to be identified early. We will formulate and implement adaptation measures to ensure that Singapore is ready to address the impact of climate change.

Climate change adaptation is also about risk management and mindsets. 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.

We will continue to improve our preparedness and strengthen our resilience to the effects of climate change over time.

CHAPTER 5

Opportunities for Green Growth

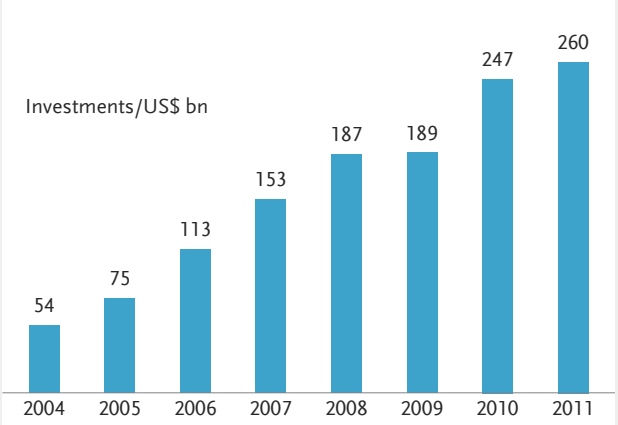
Specialists from REC performing quality control checks on the solar modules in Singapore, prior to shipment.

An REC specialist monitors the critical process parameters of solar cells production.

Climate change, fossil fuel depletion and rapid urbanisation are driving countries to deploy cleaner and more sustainable energy solutions. While climate change clearly poses significant global challenges, it also provides strong incentives for entrepreneurship, research and development (R&D) and creative problem-solving to help cities and communities anticipate, prepare for, and adapt to its impact.

Countries that are more successful in these endeavours will be better positioned to address their own national challenges, provide green technologies and solutions to other countries, and thrive in a changing world. The global clean energy market is growing at a rapid pace, with global investment in clean energy reaching US$260 billion in 2011 (see Figure 5.1).

Figure 5.1: Global Investment in Clean Energy



Source: Bloomberg New Energy Finance (2012).

Singapore—A Global Cleantech Hub

Innovation in clean technology (cleantech)[38] and related sectors depends on a critical mass of research talent, a highly trained and productive workforce, and a supportive institutional, regulatory and investment environment. Singapore, an attractive destination for high-technology investments, has built up a suite of expertise in the electronics, chemicals, precision engineering, wafer fabrication and semiconductor industries that are complementary to the development of cleantech industries.

The manufacture of solar wafers, cells and modules, for example, has many parallels with semiconductor and electronics manufacturing processes. Singapore is a major semiconductor hub—the world's top three wafer foundry companies and three of the world's top five assembly and test subcontractor companies have a presence here. Our capabilities in global equipment manufacturing, precision engineering and chemicals industries offer a head start in relevant fields, such as solar photovoltaic (PV) development.

Singapore—An Ideal Business Environment and A Global Manufacturing Hub

Singapore adopted an export-led development model to overcome the constraints of a small domestic market and lack of hinterland. Over the years, we have developed an attractive environment for companies and businesses to operate and grow.

As a result, Singapore has developed into a global manufacturing hub where multinational companies produce goods and services for the global and regional markets. Today, Singapore remains one of the most open and competitive economies globally,[39] and we continue to diversify our economy. Clean technologies and services will be a growth cluster going forward.

Locally developed entries in the 2011 Shell Eco-Marathon. From left to right: A diesel car built by Nanyang Technological University engineering students which came in first in the diesel category; and iTErbo electric vehicle constructed by Institute of Technical Education College West students.

[38] Clean technology (cleantech) comprises the fields of clean energy, environment and water, and is a key economic focus area for Singapore. Singapore's clean energy push centres on solar energy, given its location in the tropical sunbelt. There are also investments or development efforts in fuel cells, biomass, wind energy, tidal energy, energy efficiency and carbon services.

[39] The 2011 World Bank Ease of Doing Business Index ranks Singapore as the best country. Singapore is also ranked as the world's second most open economy by the 2012 Heritage Foundation's Index of Economic Freedom.

There are many opportunities for Singapore to develop as a green growth hub that provides green solutions to the world (see Figure 5.2). Singapore has the following advantages:

- A base of skilled talent and expertise for the cleantech industries and services. We will continue to develop key capabilities in R&D and human capital.
- Our compact size, regulatory expertise and institutional capabilities—making Singapore an ideal test bed for companies seeking to assess the feasibility of new technologies and processes, before scaling them up for larger markets.
- A conducive business environment, robust intellectual property regime, strong manufacturing base and capable workforce that is continually updated with the latest technologies.

Figure 5.2: Singapore's Approach towards Realising Green Growth Opportunities

Green Growth Industries Generate Value and Jobs		
Developing Capabilities (R&D and Human Capital)	Provision of Test-Bedding Opportunities	Conducive Business Environment

A Clean Energy Research Programme

In 2007, the Clean Energy Programme Office, now known as the Energy Innovation Programme Office (EIPO), was formed to develop the clean energy industry with an initial funding of S$170 million from the National Research Foundation (NRF).[40] Co-chaired by the Economic Development Board (EDB) and Energy Market Authority (EMA), this inter-agency platform comprises agencies such as the Building and Construction Authority (BCA) and the National Environment Agency (NEA).

EIPO manages various initiatives such as clean energy research, graduate scholarships, establishing research centres, and a Quickstart programme to nurture local clean energy start-ups. In 2011, another S$195 million was made available to EIPO through the NRF, to catalyse the growth of the industry by strengthening research capabilities and accelerating commercialisation.

[40] The Government has also invested in other strategic areas. For instance, in 2006, S$330 million was provided to boost the development of the local environment and water industry through R&D funding.

Developing Capabilities in R&D and Human Capital

One of the key thrusts in Singapore's long-term economic strategy is the development of capabilities in technological R&D. This will also improve our ability to take advantage of cleantech opportunities.

We will continue to strengthen our R&D expertise and human capital with the help of our tertiary and research institutions. Collaboration with top universities and institutes worldwide will facilitate research talent development and technology transfer, and create further opportunities for our graduates to pursue research careers.

Singapore's local research community has established strong R&D capabilities in cleantech.

Both the National University of Singapore (NUS) and the Nanyang Technological University (NTU) have set up specialised offices, bringing together multidisciplinary teams to develop solutions to complex and wide-ranging energy and sustainability challenges.

NUS has set up an integrated research cluster to facilitate collaboration in the area of energy and environmental sustainability. NTU's "peak of excellence on sustainable earth" programme has more than S$830 million of research funding in the area of water sustainability, alternative energy sources, clean technologies, urban systems and geological concerns.

In addition, the Agency for Science, Technology and Research's (A*STAR) Science and Engineering Research Council has identified energy and sustainability as two of its focal areas for research.

*The growing R&D scene in Singapore has created opportunities for research-related careers. Clockwise from top left: A researcher at ERI@N's Energy Storage Lab examining samples; a SERIS researcher loading silicon solar cell wafers into a diffusion furnace; simulation work at the A*STAR EPGC; a scientist at the Advanced Environmental Biotechnology Centre-NEWRI, which focuses on environmental biotechnology and bioprocesses applications for environmental issues.*

Singapore Research Institutes Working on Cleantech

Energy Research Institute @ NTU (ERI@N)
Develops industry-oriented innovations and trains specialists in clean energy. Vestas, Rolls-Royce, IBM, and Gamesa have set up joint research laboratories with ERI@N. Other partners such as Bosch, Det Norske Veritas, and Lawrence Berkeley National Laboratories are involved in joint research projects. Focus areas include: wind and marine renewables, green buildings, e-mobility, energy storage, and fuel cells.

Nanyang Environment and Water Research Institute (NEWRI) in NTU
Promotes interdisciplinary interaction and a contiguous value chain from research to translation, development and application. NEWRI provides test-bedding opportunities for industries, and hosts postgraduate programmes in environmental science and engineering. Research areas include: reduction of urban heat, waste to energy, and reduction in energy use during water and wastewater treatment, and energy from bioprocesses.

NUS Environmental Research Institute (NERI)
An interdisciplinary, cross-campus centre for environmental research. Coordinates strategic thematic research and facilitates the transfer of technology to industry. A key aim is innovative, globally impactful research on scarce resources. Current research includes: surveillance and management of environmental pollutants, environmental and health issues related to climate change, food security and safety, green chemistry, and sustainable energy.

Solar Energy Research Institute of Singapore (SERIS)
Located in NUS, SERIS conducts basic and industry-oriented research in solar energy conversion. The main R&D areas include Silicon solar cells and modules, Organic solar cells, PV module performance analysis, solar energy systems, and solar and energy-efficient buildings. The institute collaborates closely with the industry. SERIS also trains specialist manpower for the solar energy sector.

Sustainable Manufacturing Centre (SMC)
A one-stop green manufacturing knowledge hub that brings government, research and industry stakeholders together to collaborate in R&D, implement sustainable manufacturing approaches, share expertise, and transfer knowledge to the manufacturing sector. SMC is spearheaded by the Singapore Institute of Manufacturing Technology (SIMTech), an A*STAR research institute. Core research competencies include: remanufacturing, green packaging and carbon footprint assessment.

Experimental Power Grid Centre (EPGC)
An A*STAR programme undertaking R&D in areas such as intelligent and decentralised power distribution, control and management of distributed energy resources, and smart and interactive energy utilisation. Its 1-megawatt grid—one of the world's largest pilot smart grid facilities—enables researchers, industry and public agencies to develop energy technologies before bringing them to larger-scale test beds or commercialisation.

Fostering Research and Innovation

CREATE campus injects greater vibrancy to Singapore's R&D scene by bringing top global universities and institutes to Singapore.

To further develop Singapore as an innovative hub, NRF launched the Campus for Research Excellence and Technological Enterprise (CREATE) in 2006—an international research campus and innovation hub that houses research centres set up by top global universities and institutes.

Many CREATE centres are working on technologies with potential applications to climate change mitigation and adaptation, such as environmental technologies, energy storage systems, electric vehicle technologies, building energy efficiency, nanomaterials for water and energy management, waste-to-energy, and renewable energy such as solar and algae biofuels. This has given a significant boost to Singapore's R&D capabilities.

CREATE Centres

Global institutions that have announced CREATE centres in Singapore include the Massachusetts Institute of Technology (MIT), Swiss Federal Institute of Technology (ETH Zurich), Technical University of Munich, Technion Israel Institute of Technology, Hebrew University of Jerusalem, Ben-Gurion University, University of California Berkeley, Peking University, Shanghai Jiao Tong University and Cambridge University.

Centres are located near corporate laboratories, technology incubators and technology start-up companies, which facilitate close collaboration with Singapore's universities and research institutes.

TUM CREATE

Established in 2010, TUM CREATE is a collaboration between the Technical University of Munich (TUM) and Singapore's Nanyang Technological University. TUM CREATE researches innovative technologies and future transportation concepts, particularly electric transport infrastructure and delivery systems, and vehicle mobility solutions, for Singapore and tropical megacities worldwide.

One area of interdisciplinary research is advanced energy storage technologies (such as high performance batteries), a key component of electric vehicles. The aim is to reduce the cost of electric vehicles, improve their range, reduce charging time, explore wireless charging, enhance battery durability, and ensure safety.

Another current project is to design and build the world's first purpose-built electric taxi. Unlike personal cars, taxis need to run for many hours on end. Inventing a battery system that does not require overnight or frequent charging is one of the key challenges facing TUM CREATE's scientists. In Singapore, taxis make up only 3% of all vehicles, but they are estimated by TUM CREATE to consume roughly 14% of transport fuel.

The programme offers considerable potential for start-ups and spin-offs, creating jobs and further knowledge and know-how. Similar results have been achieved in TUM's home campus in Germany, where the strong cooperation between TUM and its industry partners fosters the creation of new small high-tech companies.

At TUM CREATE—an electric taxi prototype, specially designed and developed for Singapore.

Also managed by the NRF, the National Innovation Challenge on Energy Resilience for Sustainable Growth (or "Energy NIC") aims to develop cost-competitive energy solutions for deployment within 20 years to help Singapore improve energy efficiency, reduce carbon emissions and increase energy options. Announced in 2011, S$300 million is available for the first five years.

In support of the Energy NIC, a series of Technology Primers[41] were commissioned to examine the potential and relevance of various energy and climate change-related technologies to Singapore. The Primers cover technology areas such as solar energy, carbon capture and utilisation, bio-renewables, and air-conditioning systems. Building on this effort, the Primers will be developed into a series of Technology Roadmaps that will chart out the development and deployment pathways of these technologies.

Test-Bedding Opportunities

With the growth of our R&D activities, we have also developed a suite of supporting services and opportunities for firms and researchers to develop, test, and validate clean energy technologies in real-world settings. This process, known as test-bedding, can facilitate the commercialisation process for new technologies. We are well placed to serve as a "living laboratory" to test, pilot, and commercialise innovative solutions for Asian and global markets.

Several test-bedding projects are already underway, including the CleanTech Park, Electric Vehicle Test Bed, and various energy trials.

> "Addressing climate change can bring about economic opportunities in existing industries: energy efficiency efforts reduce reliance on fossil fuels and cut energy costs for companies. They also bring opportunities in the form of new industries—such as solar and wind energy research and production in Singapore, even though we have little wind resource here. And the opportunities are not in technology areas alone; they are also to be found in financing, trading, insurance and other areas as well."

MR TAN YONG SOON, PERMANENT SECRETARY (NATIONAL CLIMATE CHANGE), IN A KEYNOTE ADDRESS AT THE NUS HIGH SCHOOL SUSTAINABLE DEVELOPMENT YOUTH CONFERENCE 2011, 26 AUGUST 2011

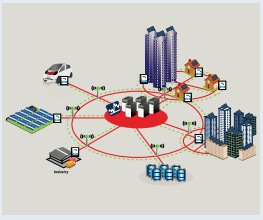
[41] Commissioned by the NCCS and NRF, an initial batch of six Primers was completed in August 2011.

Examples of Test Beds in Singapore

CleanTech Park

Green business park in the tropics

Intelligent Energy System (IES) Pilot



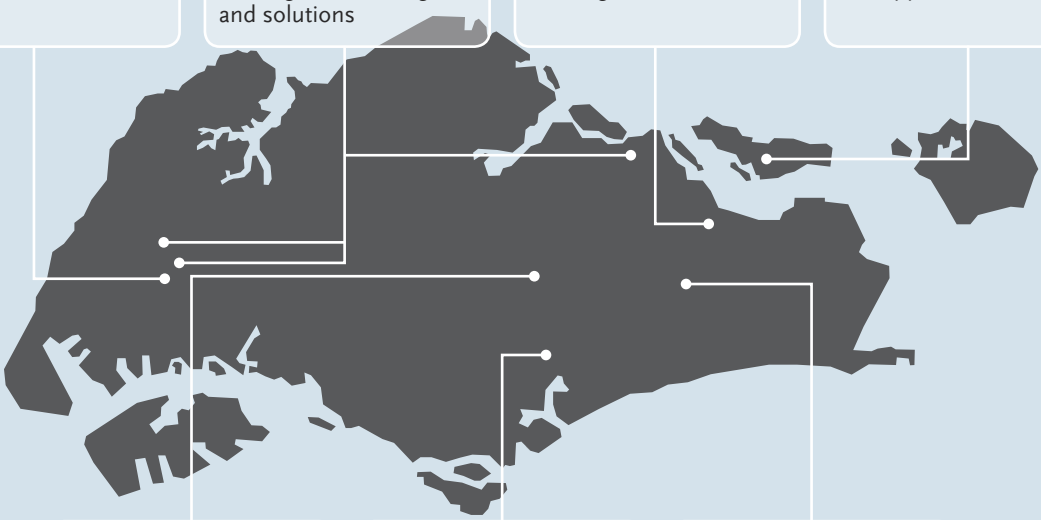
Develop and test new smart grid technologies and solutions

Punggol Eco-Town

Sustainable public housing solutions

Pulau Ubin Micro-Grid

Off-grid energy solutions and applications



Zero Energy Building

To test-bed green building technologies

Electric Vehicle Test Bed

Trials of electric vehicles and charging solutions

Solar PV Systems

Building capability for solar on public housing

Singapore—a living laboratory for test-bedding various clean energy solutions.

CleanTech Park is being developed by JTC Corporation as the first eco-business park in the region. It will cluster clean technology companies and serve as a platform for test-bedding and prototyping of clean technologies and sustainable urban solutions. The 50ha park at Nanyang Avenue will be developed in three phases over 20 years. When fully completed, it will house a working population of 20,000 green-collar workers.

Intelligent Energy System Pilot is a smart grid project led by EMA, in partnership with Singapore Power, to develop and test new smart grid technologies and solutions. This pilot will lay the foundation for an energy system in Singapore that will improve our overall energy efficiency and resilience.

Punggol Eco-Town is a real-life setting to test new urban solutions and create a green living environment. One test bed involving public-private partnership between Japanese electronics firm Panasonic and three agencies—EDB, EMA and the Housing & Development Board (HDB)—aims to integrate solar technology, lithium-ion batteries and a Home Energy Management System (HEMS) in an existing public housing block. Panasonic will install solar panels and batteries for energy storage. The system will supply electricity for lifts, water pumps and lighting in the common areas. With the HEMS, participating residents can monitor their in-house electricity usage.

Pulau Ubin Micro-Grid was spearheaded by EMA on the north-eastern island of Pulau Ubin. It will assess how clean and renewable energy can be deployed to provide reliable electricity supply to off-grid communities. This micro-grid project will also build capabilities in system integration and in managing intermittent renewable energy sources.

Zero Energy Building is a 4500m^2 BCA flagship project under the Green Building Master Plan. The building generates its own electricity from solar panels and reduces its energy needs through the use of green building technology and design. It now serves as a test-bedding facility for the integration of green building technology into existing buildings.

Electric Vehicle (EV) Test Bed is a joint project by EMA and Land Transport Authority (LTA) which evaluates the feasibility of using EVs in Singapore. Bosch was selected to provide the nationwide charging infrastructure for this test bed. Four EV models are currently available under the EV test bed: the Daimler smart electric drive, Mitsubishi i-MiEV, Nissan Leaf and the Renault Fluence Z.E.

Solar PV Systems have been rolled out in HDB public housing estates across Singapore. There will be trials in 30 precincts, and the results will allow HDB to better factor solar requirements into the design of new flats and familiarise town councils with the technical and maintenance aspects of solar installations.

CleanTech Park

The first eco-business park in Singapore, CleanTech Park is envisioned to position Singapore as a global test bed for cleantech products and solutions for tropical urban environments. Developed by JTC Corporation, the CleanTech Park is open to all types of industries that have embraced environmental sustainability. The 50ha business park brings together companies engaging in cleantech related activities to serve as a nexus for research, innovation and commercialisation in cleantech.

The development is also a large-scale integrated "living laboratory" for test-bedding and demonstrating green technologies and system-level cleantech solutions.

One of the Park's major test beds is a JTC-NTU-Philips collaboration to test and develop an intelligent and high-performance lighting system that dramatically reduces energy consumption by up to 45%, compared to conventional fluorescent lighting.

The system makes use of automated ceiling LED panels controlled by motion sensors. During the day, solar cells generate electricity for lighting, and excess electricity is stored in hydrogen-based fuel cells. To minimise energy losses, the system uses a Low Voltage Direct Current grid network instead of the standard alternating current (AC).

CleanTech Park will serve as a nexus for research, innovation and commercialisation in clean technology.

While many of the technologies being test-bedded will take some time to mature, others—such as solar energy—are rapidly improving and approaching commercial viability. For such technologies, the Government is prepared to help build industry capabilities, to scale up the technology for mass deployment.

For example, the HDB is testing solar technology in preparation for wider adoption. This will pave the way for quicker adoption of solar power when it becomes cost-competitive with energy from traditional sources. It also provides a platform for building expertise and exporting capabilities in solar PV retrofitting and integration with buildings.

We are also collaborating with other countries to develop test beds outside Singapore. China and Singapore's joint Tianjin Eco-city venture to develop a model that is "replicable, practical and scalable" for other Chinese cities and rapidly developing cities is an example. The Sino-Singapore Tianjin Eco-city project features high energy efficiency, use of renewable resources, green buildings and transportation, waste and water management, ecological infrastructure development, economic vibrancy and a good living environment.

Conducive Business Environment

We will continue to attract investments in green industries through the development of a conducive business environment.

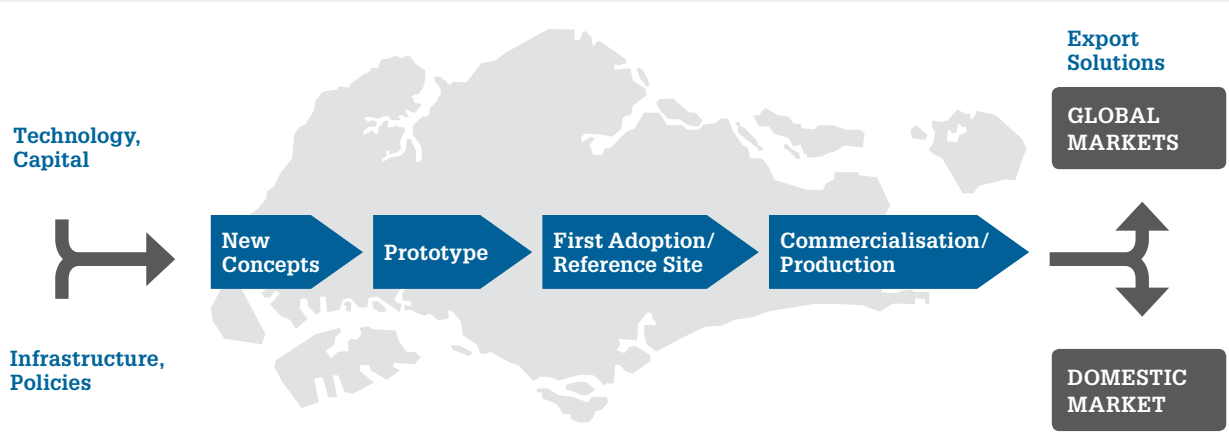
Singapore's pro-business environment has been rated highly by the World Bank and other international rankings. In addition to robust and reliable infrastructure, Singapore has a strong intellectual property (IP) regime that offers protection for companies that conduct R&D or innovation-based activities here. Our success in IP protection encouraged the World Intellectual Property Office to set up its first Asian regional office in Singapore in 2005.

In pursuing sustainable growth, Singapore has built capabilities that are relevant to other cities facing similar sustainability challenges. The National Animation Park in Tianjin Eco-city is an example.

An Ecosystem to Develop Workable Solutions

Opportunities in Singapore span the value chain: proof of new concepts in the universities, development of prototypes in research centres, and test beds for demonstration of prototypes before large-scale deployment is considered.

Besides solutions which can address the challenges faced by Singapore, we are also keen to develop solutions exportable to the rest of the world.



	Universities/CREATE	Research Centres	Test Beds	
	NUS MIT ETH Zurich Shanghai Jiaotong University **NTU** Berkeley Cambridge TUM Ben-Gurion University Hebrew University of Jerusalem	**Within NUS** NERI TMSI SERIS NUSDeltares **Within NTU** ERI@N NEWRI **Within A*STAR** SMC EPGC	**CleanTech Park** **Intelligent Energy System** **Punggol Eco-Town** **Pulau Ubin Micro-Grid** **Zero Energy Building** **EV Test Bed** **Solar PV Systems**	
Government/ Collaborating Agencies	**NRF**	**NRF** **A*STAR** **EIPO**	**NRF** **A*STAR** **EMA** **EIPO**	**EDB** **BCA** **HDB**

Schematic diagram showing the inter-linkages between initiatives.

Note: List is not exhaustive.

Opportunities for Singapore

In 2007, Singapore identified the clean energy industry as a strategic growth area and implemented a comprehensive blueprint to develop the industry. It has since grown into a vibrant sector of the economy.

Clean Technology

Within the cleantech sector, Singapore has secured several key investments in high-value manufacturing, engineering, biofuels, R&D and regional headquarters activities.

The most notable is the growing cluster of companies manufacturing and conducting R&D on solar technologies. For instance, REC has established one of the world's largest integrated solar manufacturing complexes in Singapore. The company has invested some S$2.5 billion in its first phase expansion, which will produce 800MW of solar photovoltaic modules. The Singapore facility currently employs about 1,500 employees. Yingli Green Energy, one of the world's largest vertically integrated photovoltaic manufacturers based in China, is establishing its regional headquarters and R&D centre in Singapore, to support its expansion to global markets.

REC established one of the world's largest integrated solar manufacturing complexes in Singapore.

Neste Oil has set up one of the world's largest biodiesel plants in Singapore.

Singapore is also attractive as a venue for biofuels companies. We are one of the first locations in Asia for biodiesel pricing after Platts launched daily assessments for biodiesel trading in Southeast Asia in January 2008. Neste Oil invested EUR 550 million (S$940 million) in 2010 to set up the world's largest renewable diesel plant in Singapore, with a capacity of 800,000 tonnes of biodiesel.

We are also looking into the installation of smart grid technologies to increase the operating efficiency of distributed and intermittent power generation sources such as solar energy. Devices integrated with a smart grid, such as smart meters, in-home display units and home automation networks, could give consumers greater information and control over their electricity consumption. A*STAR's Experimental Power Grid Centre is studying the management of distributed energy resources and smart energy utilisation. EMA's Intelligent Energy System pilot project aims to help Singapore deploy smart grid technologies in residential and industrial buildings in the future.

The development and adoption of energy storage technologies will allow Singapore's electricity grid to cope with intermittency issues and incorporate more renewable energy resources.

Even for alternative energies like wind and marine renewables where there is very little potential for deployment within Singapore, global leaders in these fields have chosen to base their R&D and manufacturing operations in Singapore, utilising the talent pool here to grow their operations for the Asia-Pacific markets. For instance, Vestas Wind Systems, the world's largest supplier of wind systems and a top wind technology company, opened its regional headquarters in Singapore in 2007. It will be investing up to S$500 million to develop its largest R&D centre outside of its home country (Denmark) over the next decade. The centre will employ 200 research scientists and engineers. Singapore also hosts the Asia-Pacific headquarters for Vestas.

Such R&D activities are part of an expanding and vibrant cluster in Singapore (see Figure 5.3). We aim to be a cleantech hub that provides companies with easy access to a combination of technology, markets, capital and talent.

Figure 5.3: Cleantech Clusters and Supporting Ecosystem in Singapore

Sources: Economic Development Board and Sustainable Energy Association of Singapore.

Vibrant and growing cluster of cleantech companies in Singapore.

Waste and Water Technology

Our NEWater story showcases how Singapore has addressed a vulnerable dependency on imported water. Over the last 40 years, through strategic planning and investment in research and technology, we have diversified our water supply. We now have capabilities in water management, desalination and related technologies that can help other countries better adapt to changing rainfall patterns and possible water shortages as a result of climate change.

With increasing urbanisation and growing population density in many emerging economies worldwide, climate-friendly and waste management solutions will likewise be in demand.

For example, Keppel Seghers designed, built and is operating an integrated waste management facility in the Middle East. The S$1.7 billion project includes the use of an integrated waste-to-energy concept that maximises the reuse and recovery rate from waste, and minimises the quantity of waste going to landfills.

Urban Management and Solutions

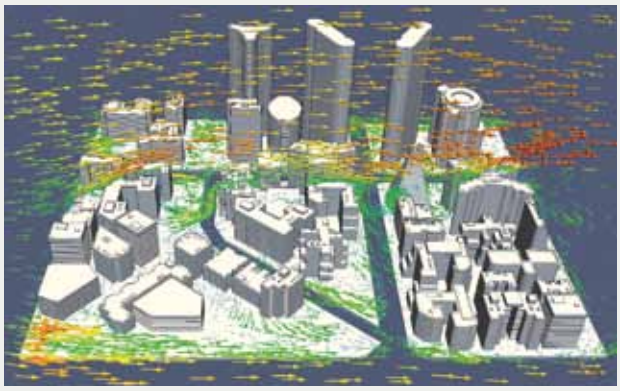
Singapore is a compact and urbanised city-state with high population density. This makes us an ideal environment to test and develop integrated urban solutions that improve energy efficiency, especially in areas such as housing, transport and co-location of related industrial activities.

Building and Urban Design

Energy-efficient building designs should incorporate passive considerations such as building orientation, sun shading and natural ventilation to minimise a building's cooling needs. For example, large windows facing prevailing winds and internal layouts that optimise air flow can improve ventilation and reduce the need for air-conditioning.

At larger urban settings, good wind flow through cities helps to remove heat build-up, and improve air quality and human comfort.

The Urban Redevelopment Authority is leading a Climatic Mapping Study, in collaboration with HDB, NUS and A*STAR's Institute of High Performance Computing (IHPC) to understand how the built environment and presence of urban greenery could affect micro-climatic conditions such as air flow and temperature.



IHPC's researchers utilised their computational science expertise and the principles of fluid dynamics to accurately model, simulate and visualise wind flow patterns in a city.

Green Information and Communication Technologies (ICT)

Singapore has a vibrant and growing ICT industry. More than 80 of the top 100 software and services companies have a significant presence in Singapore. The Infocomm Development Authority has been working with industry partners to develop green ICT solutions. This includes the development of relevant capabilities and test-bedding.

To support local companies in developing exportable ICT green solutions, International Enterprise Singapore (IE Singapore) has set up a Green Programme Office. The office helps companies to strengthen their offerings of energy-efficient ICT solutions and identifies potential market opportunities.

Green ICT

The unprecedented ownership and use of millions of ICT devices such as smartphones, tablets and laptops, each with their own power needs, results in significant levels of power consumption and carbon emissions.

In 2008, The Climate Group in its SMART2020 report found that ICT was responsible for around 2% of global carbon emissions. Green ICT solutions to improve the energy efficiency of ICT devices and data centres can lead to significant reduction in carbon emissions. In addition, green ICT also enables carbon reduction in other parts of the economy through solutions such as smart buildings and smart logistics.

Carbon Services and Climate Finance

Addressing climate change will require significant and sustained capital investments over decades. The availability and affordability of innovative financing solutions, legal and professional services, can catalyse these investments and hence support greater mitigation efforts.

With around 600 financial institutions and 9 of the top 10 international law firms located in Singapore, we are well positioned to provide financing and professional services for companies working on climate-related issues. Carbon services companies can form partnerships with these firms in Singapore as they access the regional market, develop low carbon projects, and transact in carbon credits.

As the region's top commodities trading hub, Singapore is also host to many energy majors and traders, who form a large part of the clientele for carbon services companies. Southeast Asia is one of the biggest sources of carbon credits after China and India. Singapore serves as an ideal base for companies working on carbon projects in the region.

EDB and IE Singapore are engaging carbon trading and services companies to establish and anchor a presence in Singapore. To date, there are around 30 carbon companies in Singapore, of which several have major operations here. Their activities include low carbon project development; consulting and verification services for clean development mechanism registration; carbon footprinting; and project financing and legal services.

The trading of carbon credits is supported under the Global Trader Programme (GTP) administered by IE Singapore. The GTP also covers trading in commodities such as oil, agri-commodities, metals and minerals. Companies under the GTP enjoy a concessionary tax rate of 10% or less for their qualifying trading income.

The UNFCCC/Kyoto Protocol Clean Development Mechanism (CDM) and Trading of Carbon Credits

Many countries are implementing policies and measures to curb the carbon emissions from businesses and industries. For developed countries with carbon emissions targets, companies often purchase carbon credits, which can be used to meet part of their emission reduction obligations.

The main source of carbon credits is the CDM, which allows emission reduction (or emissions removal) projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of carbon dioxide (CO_2). These CERs can be traded and sold, and used by industrialised countries to meet a part of their emission reduction targets under the Kyoto Protocol.

Operational since 2006, more than 3,900 CDM projects worldwide have been registered as of March 2012. Over 890 million CERs have been issued by UNFCCC, and another 240 million tonnes of CERs are expected from the pipeline of projects by the end of the first commitment period of the Kyoto Protocol in 2012.

Today, Asia is a key supplier of carbon credits. As of March 2012, more than 82% of registered CDM projects have originated from the Asia-Pacific region. Singapore's strategic location in the region and our pro-business environment provides an ideal base for trading and services companies in the carbon sector to develop projects in the region.

Climate Risk Management

Climate risk management encompasses a spectrum of processes including early response to distribution of resources, diversification, risk pooling and insurance, infrastructure design and capability development.

In recent years, leading insurance, reinsurance and insurance brokerage companies have established or expanded their presence in Singapore to tap on Asia's market potential. Currently, there are more than 200 insurance players in Singapore, supported by a vibrant network of global and local brokers. Singapore is a leading insurance centre in Asia and continues to develop as the region's centre for more specialised and complex insurance risks.

Singapore serves as an ideal launch pad to meet the region's insurance needs for climate-related risks. As a major financial centre, there is synergy for Singapore to develop capability in climate risk management so that the insurance sector can be better informed of regional climate risks.

Organised by the Geneva Association and into its second year, the Climate Change Summit brought together leaders in the insurance industry to discuss climate risk management.

Building Institutional Knowledge on Climate Change Science and Risk

NTU's Institute for Catastrophe Risk Management (ICRM) is the first multidisciplinary catastrophe risk management research institute of its kind in Asia. Launched in 2010, ICRM studies the vulnerabilities and the potential damages from catastrophic events. It also collaborates with other leading regional institutes in Japan and China. Through its work, ICRM helps the industry and insurance companies to better understand, model and quantify climate change risk.

ICRM works closely with the Earth Observatory of Singapore (EOS), another research institute in NTU. EOS's research seeks better forecasts of regional consequences that can be expected from global climate change, by taking into account global climate drivers active in this tropical region such as the Western Pacific Warm Pool and the Indian Ocean Dipole.

The NUS Centre for Hazards Research conducts studies on the short- and long-term effects of natural disasters, including effects of climate change, on buildings and infrastructure in Singapore, and the development of new technologies to reduce the potential risk from natural disasters.

Looking Ahead

Singapore has taken steps to ensure that we can participate in the emerging field of cleantech and other sectors relevant to the challenge of climate change. We are well placed to serve as a cleantech hub, offering many advantages and opportunities to investors as well as to local and overseas research and skilled talent. The Government will continue to see how we can best support Singapore-based businesses to develop low carbon solutions for local deployment and export. Singapore has grown a base for cleantech companies in the areas of solar, wind, fuel cells and energy storage, biomass, smart grid, marine renewables and carbon services.

Whilst technologies for carbon capture have been developed and are being tested on a commercial scale in other countries, land-scarce Singapore does not have suitable sites to store CO_2 on a large scale. Therefore, it is more practical for Singapore to explore the use of captured CO_2 as a raw material for the production of polycarbonate, polyurethane foams, acrylates, styrene and possibly methanol. In addition, as oil prices rise, there will be a demand for renewable feedstocks for biochemicals.

The innovations being developed in Singapore will help us to address our own energy and climate change challenges; they will also be useful to other cities facing similar issues. This will create high-value jobs for Singaporeans, and propel our economy along a green growth trajectory.

CHAPTER 6

Building Our Future Together: Local and International Partnerships on Climate Change

President Tony Tan Keng Yam (*front row, 6th from right*), Minister for the Environment and Water Resources Dr Vivian Balakrishnan (*5th from right*) and representatives from the people, private and public sectors with Qigong practitioners at the Green Roof of the Marina Barrage on Singapore World Water Day 2012.

Singaporeans playing a part in the fight against climate change. Clockwise from top left: Annual Recycling Week organised by the National Environment Agency. A community garden under the National Parks Board's Community in Bloom programme. A learning journey to Senoko Power Station as part of the National Climate Change Competition 2011. Green pledges collected during Ricoh Singapore's Eco-Action Day.

Climate change will affect all of us, whether directly or indirectly. Everyone—as individuals, as employees, as members of a family and as a wider community—has a stake in helping to reduce our emissions and in preparing for the effects of climate change.

Singapore's economic and environmental achievements are the result of collective commitment by our people, private and public (3P) sectors. The Singapore Government will put in place policy frameworks, public investments, information and support to facilitate our transition to lower emissions. Only by making a whole-of-nation effort can we ensure that Singapore remains resilient in a changing world, and maintains a high quality of life for generations to come.

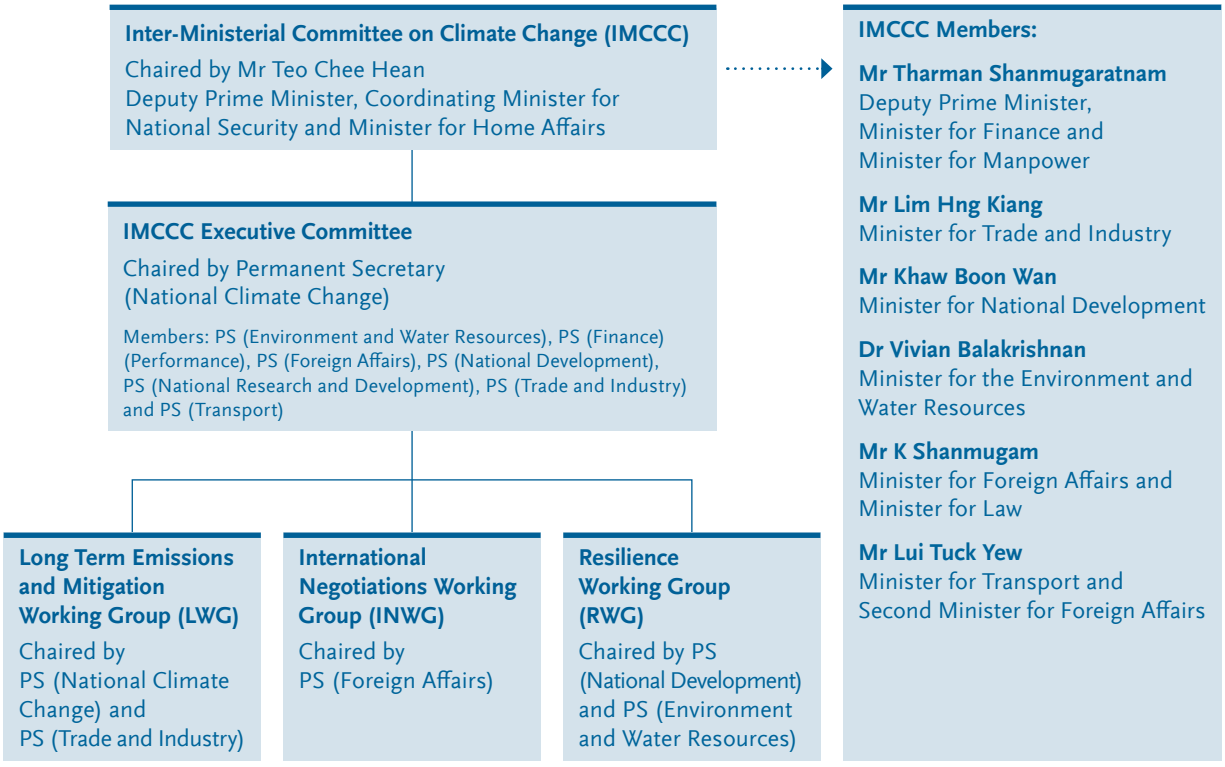
We are not alone in our task. Our many partnerships on climate issues, both at home and internationally, are helping us to better prepare for the challenges ahead, as well as to make the most of green growth opportunities as they arise.

Local Partnerships

Climate change has implications on many different aspects of human activity. For instance, significant regional changes in annual rainfall could affect areas as diverse as urban planning, buildings, transport infrastructure, food supplies and public health. Effective solutions will require coordination across many public agencies.

The Singapore Government has formed the following Committees and Work Groups to address climate change-related issues.

The National Climate Change Secretariat (NCCS) was established as a dedicated unit in July 2010 under the Prime Minister's Office (PMO) to ensure effective coordination on Singapore's domestic and international policies, plans and actions on climate change. The positioning of NCCS underscores the importance that Singapore places on climate change. Such emphasis on the environment is, however, not new to Singapore. The Anti-Pollution Unit formed in 1970 to combat air pollution was similarly placed under the PMO at the outset.



National strategy on climate change issues is shaped by an ongoing consultative and inclusive engagement with partners from all sectors. This also helps to foster awareness and action on climate change. Today, there is a vibrant and growing movement on climate change comprising individuals, businesses, non-governmental organisations (NGOs) and community groups. Coordinated efforts across the 3P sectors, working in synergy, will contribute to more effective climate change action than sporadic or isolated initiatives.

Indeed, public engagement and participation have been a hallmark of Singapore's environmental policy since the formulation of the Singapore Green Plan in 1992. It continues to be invaluable for understanding and incorporating perspectives from a diverse range of stakeholders.

Co-Creating Our Future through Public Consultation

Sustainable Singapore Blueprint

The Sustainable Singapore Blueprint (2009) set forth the strategies and initiatives for Singapore to achieve both economic growth and a good living environment over the next two decades. The Blueprint was the culmination of deliberations and consultations by the Inter-Ministerial Committee on Sustainable Development (IMCSD) and government representatives, involving members of the public, NGOs, businesses, academics, and the media over the course of one year.

The IMCSD received over 1,300 suggestions via the Sustainable Singapore website and over 700 people participated in its focus group discussions, public forums and dialogue sessions. Grassroots leaders also contributed ideas through the Government feedback agency, REACH (Reaching Everyone for Active Citizenry @ Home).

Cool Ideas for Better HDB Living

The Housing & Development Board's (HDB) Cool Ideas for Better HDB Living initiative tapped social media and competitions to crowdsource innovative solutions. Over a six-month period in 2011, Singaporeans were invited to contribute their ideas on Facebook on making clothes drying in HDB flats safer and more user-friendly. In a competition for the best ideas to conserve energy, households were encouraged to share their energy saving tips. Thirty-three student teams from local universities also took part in a design competition to develop concepts and prototypes to solve rainwater splashing, heat and noise problems.

National Climate Change Strategy 2012 (NCCS-2012)

A public consultation initiative launched by NCCS in September 2011 helped to raise public awareness of Singapore's plans to tackle climate change. The consultation spanned five months, and generated more than 1,000 comments and suggestions from members of the public, companies and NGOs.

The suggestions to reduce emissions included the preparation of a reference guide on energy-efficient practices for small and medium enterprises (SMEs); provision of more information such as usage costs on electrical appliance labels; and support for the development of a vehicle efficiency standard based on carbon emissions.

Some ideas were new and could be effectively implemented; several had already been implemented but would require greater publicity to keep the public informed of ongoing efforts, while others were found unsuitable for adoption in Singapore at this stage.

A public forum organised by the South West Community Development Council as part of the NCCS-2012 public consultation exercise.

Policies and public initiatives to address climate change will be more effective when supported by a strong foundation of social norms and environmental awareness. By helping individuals and businesses make environmentally sensitive decisions, Singapore can encourage better consumption choices, raise public transport use, and improve household electricity conservation, all of which also yield cost savings and other benefits. Outreach and educational efforts to raise awareness are necessary for the success of the overall effort in addressing climate change.

Singapore has dedicated significant attention to programmes that raise public awareness and encourage emissions reductions across all sectors. We have made information on climate-related topics relevant to Singapore more widely available. These efforts are complemented by education, capacity building and outreach programmes that highlight the importance of environmental protection and promote greater recognition for individual efforts.

> “All of us have to take ownership of our shared home... Help us to create our national plans together... because Singapore is our home and it is up to all of us to make the best of it.”

PRIME MINISTER LEE HSIEN LOONG
AT THE OPENING OF BISHAN-ANG MO KIO PARK—ABC WATERS, 17 MARCH 2012

Promoting Climate Change Awareness and Action

Entries in the National Climate Change Competition 2011 included games and comic strips with a "green" twist to spread the message on climate change action.

Series of educational brochures for the 10% Energy Challenge—providing tips on purchasing an energy-efficient air-conditioner, refrigerator and clothes dryer.

Educational Programmes

- Students are exposed to environmental education inside and outside the classroom. Climate change is discussed in subjects such as General Paper, Economics, Geography and the sciences. The curriculum is being enhanced so that students can better understand how climate change will affect Singapore.

- School excursions to power stations, incineration plants, meteorological stations and green buildings highlight the implications of climate change and practical methods to reduce emissions.

- In 2011, NCCS organised the inaugural National Climate Change Competition for schools and tertiary institutions, with the theme "Climate Change: How Can I Help?". A number of the proposals have since been implemented by the schools and tertiary institutions.

Community and National Campaigns

- The annual flagship Clean & Green Singapore campaign encourages Singaporeans to care for and protect the environment by adopting environmentally-friendly lifestyles.

- The National Environment Agency's (NEA) 10% Energy Challenge programme prompts Singaporeans to cut back on their energy consumption and adopt energy-efficient practices.

- Energy labelling schemes help consumers make informed purchases of energy-intensive household appliances such as air-conditioners and refrigerators. Similarly, the fuel economy labelling scheme provides information on the efficiency of motor vehicles in the market.

Climate Action Day organised by the Students Against Violation of the Earth (SAVE) movement of the National University of Singapore Students' Union is one of the activities supported through the NEA 3P Partnership Fund.

2011 winners of the President's Award for the Environment. From left to right: Dr Tan Wee Kiat, SMRT Corporation Ltd and Woodgrove Secondary School.

Capacity Building

- NEA's Youth Environment Envoy Programme grooms students as "green envoys" who lead their peers and the community towards greater environmental ownership.
- NEA's 3P Partnership Fund assists organisations in co-creating environmental education and outreach activities on climate change and other topics.
- Companies can participate in NEA's Corporate and School Partnership Programme to help groom young student leaders by initiating joint environmental programmes and providing mentors to transfer technical knowledge.
- The Building and Construction Authority's "Build it Green" (BiG) Club nurtures youth advocates and promotes greater understanding of green buildings. Some members have participated as student ambassadors during BCA's green building exhibitions, which are designed to give the public a glimpse into green homes and green professions in Singapore.

Recognising Green Efforts and Practices

- The annual President's Award for the Environment is the highest accolade for individuals, organisations and companies with outstanding contributions to environmental and water sustainability in Singapore. The award serves to demonstrate the Government's support and appreciation for the efforts of the 3P sectors to achieve a sustainable environment.
- NEA's EcoFriend awards recognise individuals who have contributed to protecting and improving the environment.
- The Building and Construction Authority-Singapore Green Building Council (BCA-SGBC) Green Building Individual Awards honour outstanding industry building professionals.
- Organisations which provide green products and vehicles for land transport may be recognised as the "Most Eco-Friendly Transport Partner", as part of the annual Land Transport Excellence Awards.
- MPA's Maritime Singapore Green Initiative in 2011 recognises companies that undertake environmentally-friendly shipping practices beyond what is internationally mandated.

A Vibrant Ground-up Movement on Climate Change

The Singapore Government is not alone in its quest to raise public awareness and promote action on climate change. There are many proactive individuals, businesses, NGOs and community groups who have initiated their own efforts towards responsible climate action. Public support for such action is strong and the landscape of climate change-related initiatives is rich and diverse.

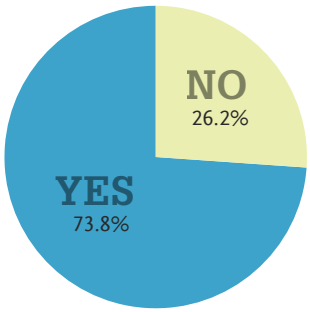
Public Perceptions of Climate Change

NCCS commissioned a survey of Singapore residents' views on climate change from October to December 2011. Based on the responses of the 1,010 Singapore residents aged 15 and above surveyed, there is strong public support for and belief in action on climate change in Singapore.

- Nearly three in four respondents (74%) indicated they were concerned about climate change.
- 63% were convinced that Singapore would be severely affected by climate change.
- A significant majority (86%) felt a sense of responsibility in playing their part to address climate change.
- A high percentage (71%) believed it was everyone's responsibility to care for the environment, with 75% motivated to adopt eco-friendly habits to preserve the environment for future generations.
- 58% of respondents felt that if global warming posed a significant threat, steps should be taken to reduce climate change even if this incurred significant cost.

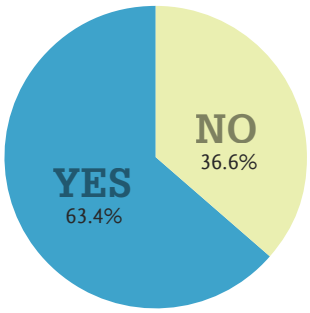
CONCERN ABOUT CLIMATE CHANGE

Are you concerned about climate change?



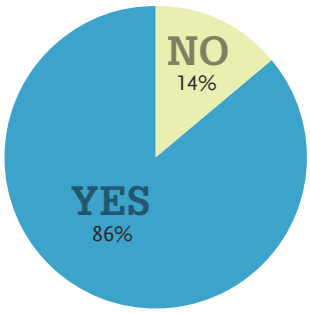
AWARENESS OF THE EFFECT OF CLIMATE CHANGE ON SINGAPORE

Do you think Singapore will be severely affected by climate change?



RESPONSIBILITY FOR TAKING ACTION ON CLIMATE CHANGE

Do you feel that you play a part in taking action on climate change?

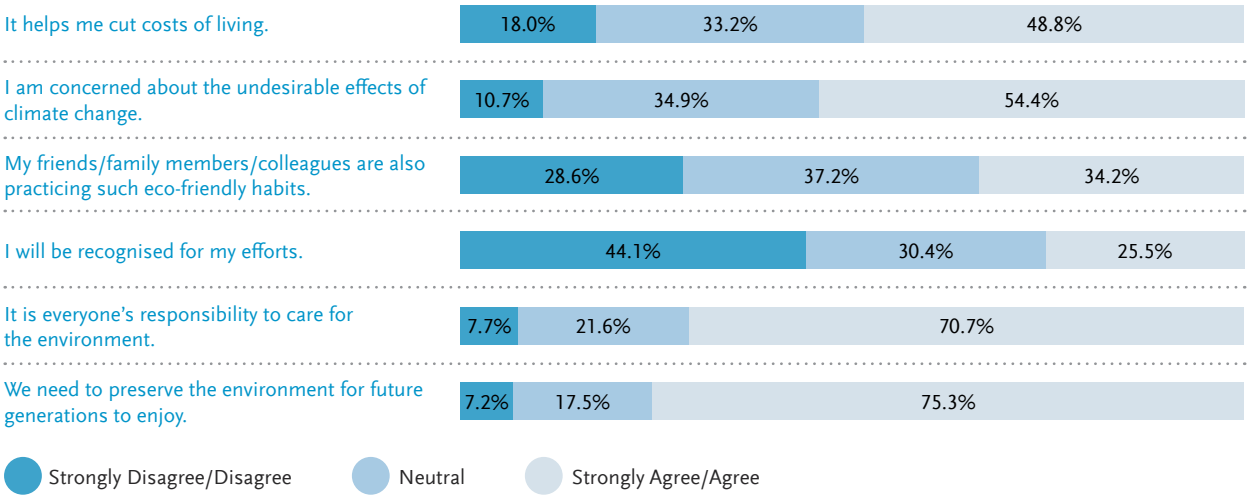


Source: Climate Change Public Perception Survey 2011.

REASONS FOR ADOPTING ECO-FRIENDLY HABITS

The following statements were rated using a 10-point scale, where 10 means "Strongly Agree" and 1 means "Strongly Disagree".

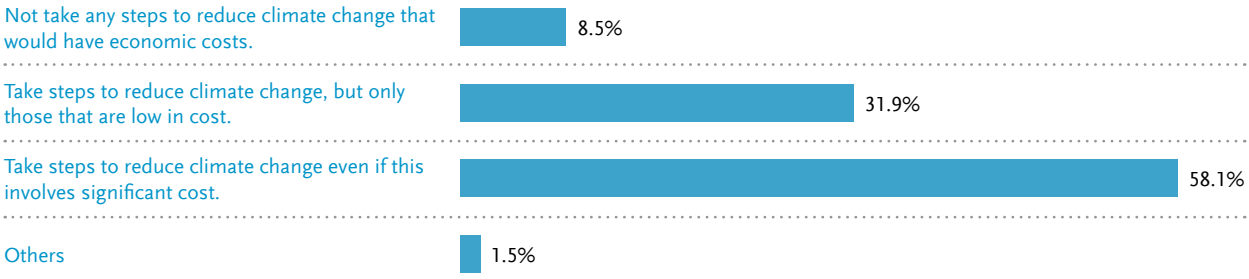
I adopt eco-friendly habits because...



TRADE-OFFS IN ADDRESSING CLIMATE CHANGE

Scientists have found that global warming is occurring and poses a significant threat.

Do you think Singapore should:



Groups of passionate individuals and NGOs play an active role in caring for and protecting the environment, as well as in heightening awareness and action by the public. Many non-governmental groups are key partners of the Singapore Government in reaching out to a wider audience.

The Singapore Environment Council (SEC), for example, organises the annual Schools' Green Audit Award to encourage students to cut down on energy and water wastage, as well as to find ways to reduce waste and recycle. It also administers the Project Eco-Office initiative to help employers implement effective environmentally-friendly practices.

The Earth Hour event by the World Wide Fund for Nature (WWF) is another NGO-led climate change initiative. Held annually since 2007, the event encourages individuals and organisations to switch off their lights for one hour on the last Saturday evening of March and go further "beyond the hour" to protect the environment. The Earth Hour global headquarters relocated in early 2012 to Singapore from Sydney, capitalising on Singapore's location and people to move the campaign forward in its global outreach.

Events such as Earth Hour organised by WWF help raise awareness among individuals and organisations about the need for action on climate change.

Harnessing the Energy of Youth

Youths form an active and important constituency for climate action.

Youth groups like the Students Against Violation of the Earth (SAVE) movement in the National University of Singapore (NUS), are undertaking awareness campaigns such as a campus-wide Climate Action Day to disseminate the green message to their fellow students. Student volunteers from NUS have also managed to convince all NUS co-operative bookstores to do away with providing free plastic bags, thereby reducing their use in the community.

Other youth groups, like Avelife, the Ci Yuan Community Club Youth Executive Committee and ECO-Singapore, have worked with the community to raise public awareness and action on climate change.

The National Youth Achievement Award Council (NYAA) has also worked with HSBC Singapore and Bayer (South East Asia) to administer awards which recognise and encourage youths to carry out environmental programmes for the community.

Ci Yuan Community Club Youth Executive Committee members explaining to a group of pre-schoolers how litter may affect our environment through a handicraft activity.

Climate Change and the Community

For Singapore's five Community Development Councils (CDCs), caring for the environment and building community engagement go hand in hand. Beyond co-organising the Clean & Green Singapore campaign with NEA, CDCs also partner their local grassroots organisations on a range of outreach programmes in areas such as energy efficiency, recycling, environmental awareness and more sustainable lifestyles. Many of these ground-up initiatives can be replicated and scaled up.

The five CDCs organise a variety of programmes to engender environmental ownership among their residents. Clockwise from top left: student volunteer training; home energy audits; lightbulb replacement programmes for low-income households as well as exhibitions and roadshows.

Community Development Councils—Forging Partnerships for the Environment

South West CDC: 1,000,000 Native Plants @ South West

A community and corporate partnership led by the CDC is working to plant 1,000,000 native trees and shrubs by November 2018, as a way to restore Singapore's natural flora, promote awareness of climate change, and encourage community bonding. A district-wide garden competition is held twice a year to recognise the best gardens, including those with the most environmentally-friendly practices.

North West CDC: A 90,000 strong Green Network by 2014

With the help of 45 community green clubs and 2,000 volunteers, the CDC hopes to reach out and educate 90,000 households to adopt sustainable lifestyles and inculcate proper recycling practices by 2014, under the Recycle @ North West programme. Funds from the sales of recycled items are used to help needy students.

The CDC is also sharing energy conservation techniques with 50,000 households. It aims to reduce the energy consumption of 10,000 households by 10%.

South East CDC: Go Green @ South East

South East CDC's GreenPlan links up key community stakeholder groups (homes, schools, grassroots organisations, and corporate organisations) to share resources and strengthen environmental efforts.

Schools and grassroots organisations participate in the Green Home AWaRE Programme, a home audit initiative to raise community awareness of dengue prevention, energy efficiency, water conservation and recycling. Students and grassroots leaders are trained to better explain how individual efforts can help address climate change.

North East CDC: ACE Plan

The Actions by the Community for the Environment (ACE) Plan encourages households to save electricity and help sustain a clean and green environment.

Through workshops and house visits, the Home Energy Ambassadors Reach Out or HEAR Me Out programme encourages more efficient household energy usage. S$85,000 has also been set aside to encourage local grassroots organisations to conduct green campaigns and promote green habits.

Central Singapore CDC: Project SWITCH

The focus of the Simple Ways I Take to Change my Habits (SWITCH) programme is energy conservation, adoption of the 3Rs (Reduce, Reuse and Recycle) and greener travel methods. Grassroots organisations and CDC staff conduct house visits to explain the impact of simple lifestyle changes.

For each customer who switches to electronic banking statements, Maybank donates $1 to a fund to help provide energy saving light bulbs to low-income families in the district, under the CDC's "S.W.I.T.C.H. to eStatement" initiative.

Deputy Prime Minister, Minister for Finance and Minister for Manpower, Mr Tharman Shanmugaratnam, with Mayor of South West District, Dr Amy Khor, at the launch of the 1,000,000 Native Plants @ South West on 23 November 2008.

The Private Sector and Responsible Corporate Action

The global trend towards corporate social responsibility has prompted many businesses to do their part to reduce emissions and care for the environment. Proactive businesses have adopted more resource-efficient practices, which not only reduce emissions but also help their corporate bottom lines by cutting waste. Firms also contribute through efforts to clean up and safeguard the environment. They also support efforts by the people and private sectors, through sponsorship or corporate volunteers.

Singapore-based firms are part of this growing trend. Industry associations and professional bodies such as the Singapore Stock Exchange, Association of Certified Chartered Accountants, the Singapore Business Federation and the Singapore Compact are advocating environmental stewardship as an expression of good corporate citizenship. They have encouraged their members to adopt a triple bottom line approach in their operations, by not just focusing on the financial aspects of the business, but the environmental and social aspects as well.

Companies are also encouraged to report their sustainability efforts, and some companies like Singapore Airlines and Singapore Telecommunications Limited (SingTel) have issued annual sustainability reports.

The Corporate Sector—Doing its Part to Care for the Environment

City Developments Limited (CDL), a property developer based in Singapore, has been incorporating sustainable business practices and promoting green outreach programmes as part of its corporate social responsibility policy. Eco-friendly features such as energy saving lights, pneumatic waste disposal system and recycling corners are in CDL residential developments. CDL also developed City Square Mall, Singapore's first eco-mall, and the first commercial project to receive BCA's Green Mark Platinum Award.

Beyond building and managing properties with environmental sustainability in mind, CDL has gone the extra mile to influence its consultants and contractors to do their part. CDL has been actively supporting governmental agencies, NGOs, the youth, and the community at large to promote environmental awareness. Through initiatives such as Project Eco-Office and Let's Live Green, CDL helps to cultivate eco-friendly habits both in the office and at home.

Senoko Energy has been promoting and adopting environmentally-friendly business policies within the Singapore power generation industry. The company was the first to use natural gas for electricity generation in 1992, and replaced its less efficient oil-fired plant with high-efficiency gas-fired Combined Cycle Plant. This resulted in a reduction of 2.5 million tonnes of carbon dioxide per year. It has also invested in a desalination plant to achieve self-sufficiency in its water needs, and has implemented waste reduction, reuse and recycling programmes throughout its premises.

As part of its community engagement efforts, Senoko constantly encourages its business partners to adopt energy efficiency and water conservation measures. It partners schools to instil students with greater environmental consciousness through initiatives such as its own National Weather Study Project and PUB's Our Waters Programme. It has also worked with the Singapore Environment Council to promote sustainable businesses through the SEC-Senoko Power Green Innovation Awards.

International Partnerships

As climate change is a global challenge that requires coordinated global action, Singapore collaborates actively with international partners through various multilateral, regional and bilateral platforms.

In support of the multilateral system for climate change, Singapore participates actively in the ongoing cooperative efforts under the UN Framework Convention on Climate Change (UNFCCC) and other UN specialised agencies.

As part of a holistic multilateral response to climate change, Singapore is also active in platforms such as the World Trade Organisation (WTO), World Intellectual Property Organisation (WIPO), International Maritime Organisation (IMO) and International Civil Aviation Organisation (ICAO) to help develop measures in their respective sectors to respond to climate change. Additionally, we share our experiences on sustainable development at fora such as the Asia-Pacific Economic Cooperation (APEC) and the Association of Southeast Asian Nations (ASEAN).

For instance, as a major maritime and aviation hub, Singapore strongly supports the leadership of the ICAO and the IMO in developing global measures to address emissions from international aviation and maritime transport, while allowing for sustainable growth of these sectors. Singapore has and will continue to participate actively in the efforts of ICAO and IMO to address greenhouse gas emissions from their respective sectors.

The Maritime and Port Authority of Singapore (MPA) launched the Maritime Singapore Green Initiative in 2011 to recognise companies that undertake environmentally-friendly shipping practices beyond what is mandated by the IMO. MPA has committed up to S$100 million over five years to support the Initiative.

> “As responsible members of the international community, we must not miss this opportunity to work together to arrest climate change—for the sake of our children and successive generations.”

DEPUTY PRIME MINISTER TEO CHEE HEAN DELIVERING SINGAPORE’S NATIONAL STATEMENT AT THE UNFCCC COP-17/CMP7 CLIMATE CHANGE CONFERENCE HIGH LEVEL SEGMENT IN SOUTH AFRICA, 7 DECEMBER 2011

Singapore has also actively supported the ICAO's efforts to address international aviation emissions. In 2009, Singapore chaired the ICAO High Level Meeting on International Aviation and Climate Change which endorsed a Programme of Action (PoA) that aims to achieve a global fuel efficiency improvement of 2% per year until 2020, and sets out a similar aspirational goal from 2021 to 2050. In October 2010, the 37th ICAO General Assembly agreed to the fuel efficiency goal and endorsed supporting initiatives including improvements to air traffic management processes, setting carbon dioxide standards for new aircraft and adopting market-based measures under a global framework. Singapore continues to help advance the ICAO's work by contributing expertise to its Expert Groups for the development of State Action Plans and market-based measures.

Singapore has joined the C40 Cities Climate Leadership Group (C40) as an observer city. The C40 is a network of 58 cities (including Berlin, Hong Kong, Jakarta, Johannesburg, Los Angeles, London, New York, Sao Paulo, Seoul and Tokyo) committed to implement sustainable climate-related actions locally that will address climate change globally. C40 collaborates with organisations such as the World Bank, OECD and the Clinton Climate Initiative. Singapore's ongoing work to mitigate climate change, including our clean water system, has been noted as being useful for cities around the world. Our involvement in the C40 will allow us to share our experience on sustainable development, and learn from the best practices of other major cities.

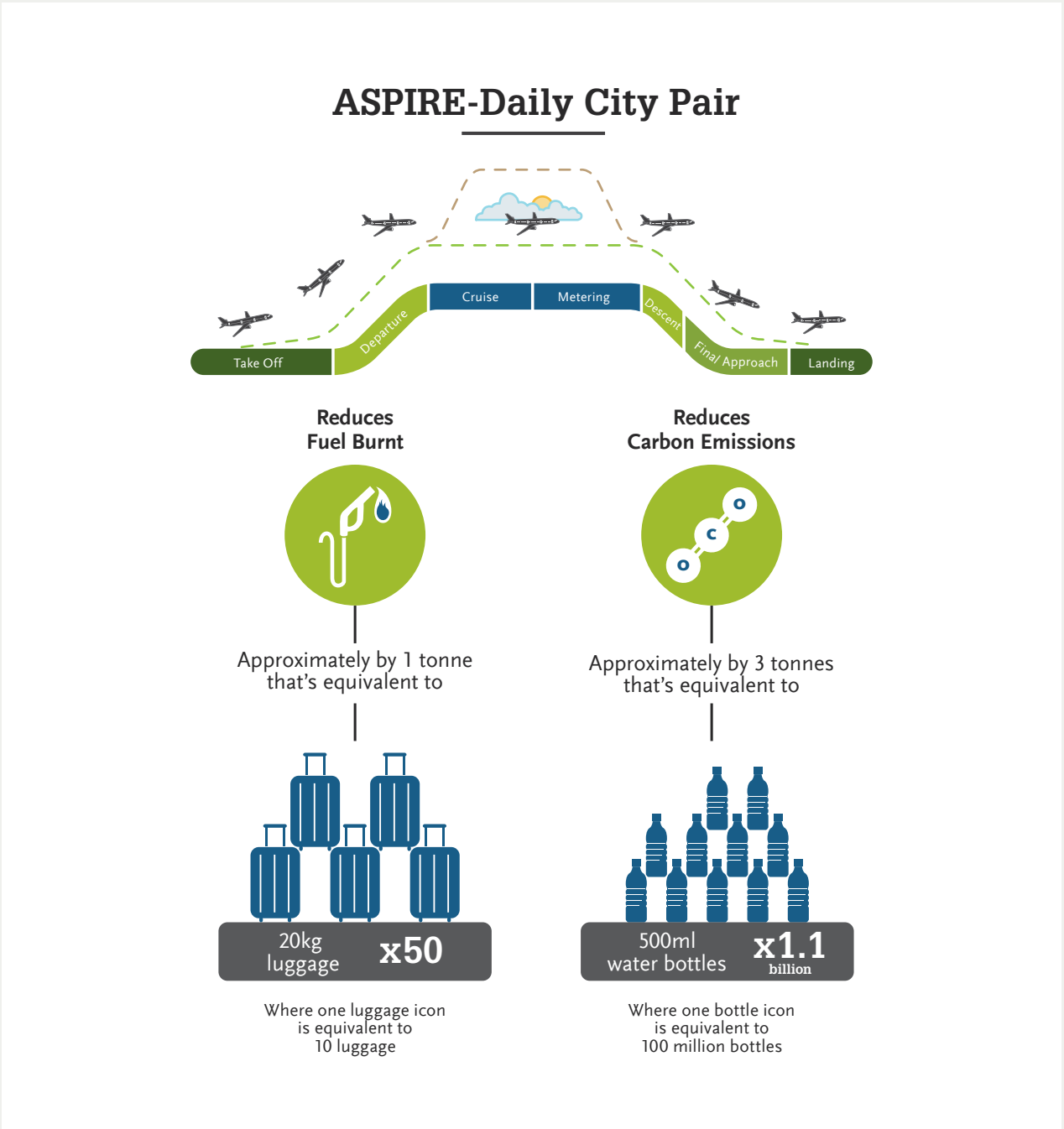
At the bilateral level, key examples of Singapore's environmental cooperation efforts include the Sino-Singapore Tianjin Eco-city Project with China, as well as improving peat land management and promoting sustainable land use practices in Jambi Province, Sumatra, with Indonesia.

Going Green in the Aviation Sector

Singapore is a member of the Asia-Pacific Initiative to Reduce Emissions (ASPIRE), a multilateral partnership of air navigation service providers which aims to promote "green" flight operations through collaboration in air traffic management across the Asia Pacific.

One of the group's initiatives is the "ASPIRE-Daily City Pair" programme which promotes best air traffic management practices for gate to gate operations between city/airport pairs for daily flights. The ASPIRE "city pair" between Los Angeles and Singapore on the daily Singapore Airlines non-stop flight (SQ37) was among the first when it was launched on 16 May 2011. This was made possible by the close collaboration between the Civil Aviation Authority of Singapore, Singapore Airlines, the United States Federal Aviation Administration and the Civil Aviation Authority of the Philippines. SQ37 employs enhanced air traffic operational procedures in all phases of the flight—from push back at the gate in Los Angeles to taxiing, take-off, cruising, continuous descent arrival and taxiing back to the gate at Changi Airport. This initiative reduces fuel burnt by approximately 1 tonne (equivalent to 50 pieces of 20kg luggage) and carbon emissions by approximately 3 tonnes (equivalent to 1.1 billion 500ml water bottles) on each Los Angeles-Singapore flight.

Singapore also participates in the Airport Carbon Accreditation programme, an initiative by the Airports Council International (Asia Pacific) and supported by the International Civil Aviation Organisation (ICAO). Under this initiative, the Changi Airport Group will work towards reducing its carbon emissions to eventually achieve carbon neutrality.


ASPIRE-Daily City Pair
Take Off
Departure
Cruise
Metering
Descent
Final Approach
Landing
Reduces
Fuel Burnt
Approximately by 1 tonne
that's equivalent to
20kg
luggage
x50
Where one luggage icon
is equivalent to
10 luggage
Reduces
Carbon Emissions
O
C
O
Approximately by 3 tonnes
that's equivalent to
500ml
water bottles
x1.1
billion
Where one bottle icon
is equivalent to
100 million bottles

Sino-Singapore Tianjin Eco-City

Left: Then-Senior Minister Goh Chok Tong with China Premier Wen Jiabao at the Sino-Singapore Tianjin Eco-city Groundbreaking Ceremony on 28 September 2008. Right: Aerial view of Tianjin Eco-city.

Singapore is collaborating with China to build an Eco-city in Tianjin. The vision is to develop a thriving city that is socially harmonious, environmentally-friendly and resource efficient—a model for sustainable development.

Singapore's contribution involves sharing expertise and experience in areas such as urban planning, environmental protection, resource conservation, water and waste management and sustainable development, and community development programmes. For example:

- Singapore's Urban Redevelopment Authority (URA) formulated Tianjin Eco-city's masterplan together with its Chinese counterparts.
- Singapore's HDB worked closely with the Tianjin Eco-city Administrative Committee (ECAC) to formulate the public housing policies for the Eco-city.
- Singapore's PUB and the ECAC co-developed a set of "Integrated Water Management Guidelines" for the Eco-city covering water conservation, water safety and quality, and sanitation and drainage, to help address the water challenges faced by the Tianjin Binhai New Area and Bohai Rim.
- Singapore's BCA collaborated with ECAC to formulate Tianjin Eco-city's Green Building Evaluation Standard.

Singapore and China have also jointly determined a set of performance indicators to measure the success of the Eco-city in the long term. These include:

- At least 20% of the energy utilised in the Eco-city will be in the form of renewable energy;
- 100% green buildings;
- Less than 150 tonnes of carbon emission per one million US$GDP;
- 100% potable water from taps;
- At least 50% water supply from non-traditional sources;
- At least 60% overall recycling rate; and
- At least 90% of trips within the Eco-city are green, i.e., via non-motorised transport and public transport.

Sino-Singapore Tianjin Eco-city Investment and Development Company, a joint venture company formed by a Singapore consortium and a Chinese consortium, is the master developer for the project. The project is undertaken by the private sector to ensure that it is commercially viable. Developed according to the principles of being "replicable, practicable and scalable", it aims to serve as a sustainable development model that other Chinese cities could emulate.

Singapore-Indonesia Collaboration Efforts in Jambi

Singapore helped set up automated air quality and weather monitoring stations in Jambi Province. It also enhanced aquaculture expertise in Jambi by organising a freshwater aquaculture training workshop. The workshop, featuring lessons on water quality management and fish feed production, helped farmers improve the efficiency and efficacy of their production methods, lower their operational costs and thereby increase their income.

Singapore also implemented the Jambi Peatland Management Knowledge Base and Training Programme. This programme aims to reduce fires in peatlands through science-based implementation of mitigative water management and conservation methods, and features international experts on peatland management to develop training programmes, awareness building and guidance materials for proper peatland management in Muaro Jambi Regency.

Example of a sustainable-peatland mangement project—fish farming project in Jambi offers locals an alternative livelihood.

The first workshop was held in 2009 at the Jambi University, involving peatland managers, engineers and government officials from Jambi. A second workshop was held in 2010.

Conclusion

Collectively, our actions and partnerships will enable Singapore to address the climate change challenge more effectively. The Singapore Government will continue to work with stakeholders in the 3P sectors on our climate actions and outreach efforts.

Singapore will also continue to collaborate actively with international partners as part of a coordinated global effort.

CONCLUSION

Stepping Up to Climate Change

The world must act to avoid the worst effects of global warming and climate change. Collectively, developed and developing countries have to step up mitigation efforts to substantially reduce global carbon emissions.

The Need to Act

Both developed[42] and developing countries[43] have started to implement measures to reduce their emissions. Singapore has started implementing measures outlined in this Strategy document to reduce our carbon emissions by 7% to 11% below the 2020 business-as-usual (BAU) level. When a legally binding global agreement on climate change is reached, we will implement additional measures to achieve the reduction of 16% below BAU by 2020. The United Nations Climate Change Conference in Durban in 2011 reached an agreement to complete negotiations "no later than 2015" to reduce emissions for the post-2020 period. The new binding global agreement for the post-2020 period will require all countries to do more and adapt to the reality of a low-carbon future.

The extent to which countries can reduce their emissions will depend on their natural endowments, available resources, and current and foreseeable technological possibilities. The International Energy Agency (IEA) has assessed that being more efficient in the use of energy offers the biggest scope for cutting emissions up to 2030 and will remain a significant source of emissions reductions thereafter.

Post 2030, there is greater scope for innovation and new technologies to provide solutions for low-carbon growth. In particular, renewable and clean energy sources have the potential to provide low-carbon, sustainable power that can also reduce dependence on fossil fuels. Some countries which are well endowed with renewable energy resources are aiming for an entirely fossil-free energy mix in the long term. For example, Denmark seeks to achieve more than 35% renewable energy in fuel energy consumption in 2020, and ultimately 100% renewable energy use by 2050, mainly from wind and biomass. Less well-endowed countries have set lower targets. UK aims to meet 15% of its energy needs in 2020 from renewable sources. Yet, there are still others, including Singapore, which are extremely poorly endowed and have limited scope for deploying renewable energy. Fossil fuels will therefore continue to meet a large proportion of global energy needs for the foreseeable future.

While Singapore is disadvantaged by our lack of renewable energy sources, this will not hold us back from intensifying our emission reduction efforts. We need to be bold and long-term in our vision, planning ahead, innovating and implementing environmentally responsible policies. Singapore has overcome many challenges to thrive and build an environmentally-friendly city despite our land and resource constraints. Addressing the climate change challenge will again require our collective commitment so that we can continue to flourish in a low-carbon world.

[42] Refer to http://unfccc.int/resource/docs/2011/sb/eng/inf01r01.pdf for economy-wide emission reduction targets to be implemented by developed countries.
[43] Refer to http://unfccc.int/resource/docs/2011/awglca14/eng/inf01.pdf for plans by developing countries to limit their growth in emissions.

Preparing for the Future

Beyond the measures we have identified to mitigate carbon emissions up to 2020, Singapore needs to work on three fronts: First, further enhance energy efficiency and energy conservation in all sectors. Second, develop and leverage technological solutions to harness renewable energy more effectively. Third, change user behaviour through effective policies, incentives and price signals.

We will also enhance our resilience to climate change.

Enhancing Energy Efficiency and Conservation

In Singapore's context, energy is a strategic resource because we are almost completely reliant on external energy sources to support economic activity and growth. Nonetheless, we can moderate emission growth if we conserve energy more aggressively. In fact, this is essential as the price of oil and gas will rise over time with increasing global demand.

As a compact and urbanised city-state with high population density, we can further develop integrated urban solutions that promote energy efficiency, especially in areas such as housing, transport and co-location of related industrial activities.

Improvements in technology can continue to drive more efficient use of energy. For example, there is scope to improve energy efficiency for air-conditioning, which can take up to 50% of the total energy consumption of a building today. With our research and development (R&D) efforts, there is also potential to reduce the energy needed for desalination by more than 50%. This will help us meet future water needs without increasing energy demand.

Leveraging Technology and Innovations

To reduce emissions over the long term, the Singapore Government will invest in research and development in renewable energy. R&D in solar energy is one area of emphasis, for example to take advantage of solar photovoltaics whose cost is widely expected to come down over time. This will help to mitigate Singapore's current lack of viable significant renewable energy alternatives. Nonetheless, given the limited land area in Singapore, renewable energy is likely to meet a relatively small proportion of our overall energy needs.

Singapore will continue to study energy options such as electricity imports and nuclear energy. Given our energy constraints, it is important to keep longer term options open in order to be ready to add new sources to our energy mix should they become viable.

A benefit of our small size is our ability to coordinate and implement policies, innovations and solutions quickly. Singapore has become a living laboratory for the research, development and test-bedding of novel solutions. We need to be bold and far-sighted in pursuing and harnessing new technologies, and making environmentally-friendly lifestyle and consumer choices.

Changing User Behaviour

We should continue to encourage energy conservation. The Energy Conservation Act to be implemented in 2013 will require heavy users of energy[44] to designate an energy manager, monitor and report their energy use and greenhouse gas emissions, and submit energy efficiency improvement plans. Over time, the legislative framework will be refined to take in experience and feedback.

Price signals and incentives will also help to encourage energy efficiency. Energy should be priced correctly, including the costs of environmental impact and energy security concerns, to discourage excessive use or wastage. Carbon pricing can reinforce existing measures to promote energy conservation and energy efficiency, and encourage investments in energy-efficient and low-carbon solutions. The European Union, Switzerland, Australia, New Zealand, British Columbia, California and Tokyo have implemented carbon pricing schemes, whilst South Korea and China are considering similar schemes. Offset and support measures often form part of the package—to help businesses take action on sustainability issues and address emissions, and to help households make adjustments and informed choices to become more energy efficient.

If it is necessary to use price as a lever to drive greater energy consciousness, we will have to study the relevant details including offset packages carefully. The Singapore Government will adopt a pragmatic approach and pace the implementation of policies appropriately so that our economy and people can adapt.

Enhancing Resilience

To enhance our resilience against climate change, Singapore has raised the minimum levels for new reclamation projects and made plans to protect our coasts and improve our flood management system. Singapore has also developed a diversified water supply strategy to include NEWater and desalinated water, which would allow us to meet Singapore's future water demand and increase our resilience to dry spells.

Singapore is further developing our climate science capability and studying the diverse impact of climate change on coastal land, water resources and drainage, biodiversity and greenery, public health, and energy demand and urban infrastructure, so as to develop appropriate adaptation measures and enhance them over time.

[44] The Energy Conservation Act covers energy users above the threshold of 15 gigawatt-hours equivalent or 54 terajoules of energy per year.

Creating Green Growth Opportunities

The Inter-Ministerial Committee on Climate Change has established a Long Term Emissions and Mitigation Working Group to envision Singapore's post-2020 future and study how we can stabilise our long-term emissions in a low-carbon world. This will be challenging, given Singapore's limited ability to draw significantly on alternative energy sources. Nevertheless, we have successfully tackled other environmental challenges in the past—such as our water supply—through conservation and by developing and deploying innovative solutions to meet our needs and national circumstances.

The Long Term Emissions and Mitigation Working Group will address several key issues:

- What are the energy efficiency and technological possibilities in the various sectors?
- How can Singapore maximise our ability to harness renewable energy, in spite of our geographical constraints?
- What are our long-term energy options, and how might these change as technologies evolve?
- Can we leverage low-carbon power in the region in future, such as hydro and wind sources?
- What supporting policies and new capabilities do we need to stabilise our emissions in the long term? What steps must we take today, to meet this challenge tomorrow?

Singapore needs to study how our economic strategies and industrial structure can best respond to, and take advantage of, a low-carbon future. We should create and tap on green growth opportunities, and grow the cleantech industry.

Towards a More Eco-Friendly Singapore

What will the Singapore of the future look like? Singaporeans will enjoy a clean and green environment, and a high quality of life in a city within a garden. There will be more eco-friendly new towns like Punggol, with an efficient public transport system, innovative use of space for waterways and parks, and vertical greening. Within existing public housing estates, residents can also enjoy eco-friendly technologies and solutions as these become available.

Our industries and buildings will become much more energy efficient and make use of advanced carbon efficient processes and green features. An increasing proportion of our workforce will be employed in the cleantech industries, benefitting from the growth of Singapore as a cleantech hub with strong government support.

Our infrastructure will be complemented by "software" improvements. There will be greater environmental awareness amongst people, households and companies, and more of them will adopt eco-friendly lifestyles—the 3Rs (reduce, reuse, recycle) and energy conservation will become part of the Singaporean way of life.

Shaping Our Future through Collective Action and Partnerships

This Strategy document has set out what Singapore has already done, what we are doing now, and what we are planning to do in the future. Through this document, we seek to raise awareness about the impact of climate change, and encourage everyone to make a difference through our choices and actions every day—in our homes, workplaces and communities.

Addressing the climate challenge will require concerted effort from everyone in Singapore. The Singapore Government will provide the framework for mitigating carbon emissions, but success will depend on the actions by individuals, the community and businesses to explore and take up new opportunities, ideas and solutions. Concurrently, to enhance our resilience to the impact of climate change, the Singapore Government will invest in capabilities in climate science and adaptation options, and build partnerships with people as well as local and foreign institutions and experts.

We will need strong people, private and public partnerships, both domestically and internationally, in order to meet the multifaceted challenges of climate change.

Vision for Singapore

Our vision for Singapore is a climate resilient city that is well positioned for green growth. We are building a modern city within a garden in spite of our natural and geographical realities as a small city-state.

The steps we take collectively as a nation today will ensure that Singapore remains a vibrant and liveable nation, a home that is flourishing and enduring for this and future generations.

Prime Minister Lee Hsien Loong interacting with students at the opening of Bishan-Ang Mo Kio Park on 17 March 2012.

IMAGES CONTRIBUTED BY:

Agency for Science, Technology and Research (A*STAR)
Asia Insurance Review
Building and Construction Authority (BCA)
Central Singapore Community Development Council
City Developments Limited
Ci Yuan Community Club Youth Executive Committee
Energy Market Authority (EMA)
Electric Vehicle (EV) Taskforce
Housing & Development Board (HDB)
Institute of Technical Education (ITE)
JTC Corporation (JTC)
Keppel Corporation Limited
K-Reit Asia
MediaCorp Press Ltd
Meteorological Service Singapore (MSS)
Ministry of National Development (MND)
Ministry of the Environment and Water Resources (MEWR)
Nanyang Technological University (NTU)
National Environment Agency (NEA)
National Parks Board (NParks)
National Research Foundation (NRF)
National University of Singapore (NUS)
Neste Oil Corporation
North East Community Development Council
North West Community Development Council
PUB, Singapore's National Water Agency
REC
Ricoh Asia Pacific Pte Ltd
SBS Transit
Singapore LNG Corporation Pte Ltd
South East Community Development Council
South West Community Development Council
TPGS Green Energy
TUM CREATE
UN Photo 179492 / H. Tzovaras
WWF Singapore

NCCS

NATIONAL CLIMATE CHANGE SECRETARIAT
PRIME MINISTER'S OFFICE SINGAPORE