

2008 Primer

Reducing Vulnerabilities to Climate Change Impacts and Strengthening Disaster Risk Management in East Asian Cities

I/ CITY DESCRIPTION

Located in south-east Asia, the city-state of Singapore came into existence after its separation from the Malaysian Federation on August 9, 1965. A small country with an area of 697.2 square kilometers (km²), Singapore is an archipelago consisting of 63 islands. The country is surrounded by Malaysia to the north and Indonesia to the south-east. The highest peak in Singapore is the Bukit Timah that rises up to 164 meters. Singapore is thus essentially a coastal country and a member of the “small island” category of countries.

Singapore has an estimated population of 4.59 million (2007 data) with annual growth of 4.3 percent. The resident population of Singapore is approximately 3.58 million; the population annual growth is 1.6 percent. Life expectancy at birth is 80.4 years (2007 data) and compares favorably with that of OECD countries. The literacy rate of 95.4 percent (2007 data) is also comparable with that of OECD countries. The population trends indicate that Singapore has a rapidly increasing population that is being fueled mainly by immigration than natural growth. A key characteristic of Singapore, the support ratio (i.e., the ratio of population between 15-64 and over 65) has fallen from 17.0 to 8.5 between 1970 and 2007. This indicates that the country’s population has steadily aged between these years. The rapidly increasing proportion of the country’s population is a manifestation of its economic advancement in the recent decades. At the same time, it reflects the greater proportion of aged and potentially vulnerable population to various natural disasters and climate change-related impacts.

A. Economic Indicators

Singapore is one of the major economic powerhouses in east and south-east Asia. The country’s gross domestic product (GDP) is S\$243 billion (2007) and the per capita annual income is nearly S\$53,000.¹ As a recently industrialized economy, Singapore boasts of low unemployment (3.1 percent) and high growth rate (7.7 percent). Only around 17 percent of the population is engaged in manufacturing jobs while another 12.4 percent are in business services. Most of the working population is therefore engaged in white-collar jobs indicating the mature nature of its economic activity that relies strongly on a service economy. Singapore has been recognized as a major international financial center and employs around 6.1 percent of its working population in financial sector jobs.



Singapore is one of the major economic powerhouses in east and south-east Asia.



**Global Facility for
Disaster Reduction and Recovery**



International Strategy for
Disaster Reduction

A major contributor to Singapore's economy is tourism. Singapore is recognized as an important tourist destination and is also a major transit point for travel between East Asia and Oceania and Europe, Africa, and the Middle-east. Over 10 million tourists arrive in Singapore each year, in addition to a much larger number that use Singapore as a transit point in their journey to change aircrafts.

The economic activities, particularly related to the service economy and finance, are sensitive to disaster risk and the impact of climate change. Singapore thus has a significant concern regarding the impact of these on its future development and growth.

B. Urban Poor & Singapore Social Housing

The urban poor are extremely vulnerable to disasters and have the lowest resilience to disruption due to the disaster. The urban poor therefore require special consideration and analysis. Singapore has an unusually low level of urban poverty. The World Development Report (2008) does not record any Singapore population living below the poverty line (equivalent to US\$1 per day). The UNDP Human Development Report² has ranked Singapore number 25 in 2007-2008, however its Human Poverty Index rank is 7th among 108 developing countries that were ranked.³ The poverty level in Singapore thus appears to be negligible when compared to other countries. While Singapore does not have an official poverty line, various studies indicate that around 150-300 people live on streets every year. Most of these people are old and without any skills. Some street people have been abandoned by their family. Other studies indicate that about 4 percent of Singapore's resident population lived at or close to the poverty line in 1998.⁴

The number of homeless people in Singapore is much lower than the number of poor people. The poor people have been taken off the streets due to some visionary policies formulated in the early years of Singapore's independence that has placed emphasis on housing as a commitment of the government to its people. Even the poorest are not excluded from public housing in Singapore. The public housing authority, the Singapore Housing Development Board (HDB), indicated that in 2004 around 38,000 households were not able to buy their

own flats or rent in the open market and occupied heavily subsidized 1- and 2-room public rental units under their Public Rental Scheme.

The approach of Singapore in handling the problem of affordable housing is in stark contrast to those of other developing countries that have viewed affordable housing as a social problem that can be tackled after achieving economic progress. On the other hand, Singapore viewed these two problems of social and economic progress as of equal importance. The Government therefore has initiated a two-pronged approach to enable housing for all in Singapore: (a) to provide housing of sound construction and good design for the lower-income groups at rents which they can afford, and (b) to encourage a property-owning democracy in Singapore to enable Singapore citizens in the lower- and the middle-income groups to own their own houses.

C. Political and Governance Structure

Singapore is a parliamentary democracy and is ruled by a Prime Minister and Cabinet who are appointed by the President and are responsible to the Parliament. The details regarding the political and economic governance structure given below have been excerpted from <http://www.edc.ca>.

(1) General Political Environment

The ruling People's Action Party (PAP) has dominated Singapore politics since independence in 1965. It is a solidly pro-Western, pro-business party with a track record of very efficient economic management. The PAP won its tenth successive mandate in legislative elections held in 2006 where it took 82 of 84 seats. It garnered 67 percent of the popular vote, down from 75 percent in the 2001 election. This was the first election in 18 years where there were enough opposition candidates standing for election that the PAP victory was not a foregone conclusion. Despite the decline in the PAP share of the vote, Prime Minister Lee Hsien Loong received a clear mandate.

The PAP Government's overall approach to dissent is one that focuses on stifling criticism and undermining opposition voices. The Government closely monitors opposition activities and frequently uses tools such as arbi-

trary arrest, the imposition of large fines, or the initiating of lawsuits against opposing parties whenever it can. A day after the May 2006 election, the PAP charged that a prominent candidate for the Workers' Party, James Gomez, was attempting to besmirch the Government's integrity after wrongly claiming that his election forms had been lost. In June 2006, police charged the leader of the Singapore Democratic Party and two supporters with violating the peace for speaking in public without a permit. Despite being a parliamentary democracy, the media in Singapore is strictly controlled. Singapore faces increasing though sporadic international criticism for its heavy handedness and stifling of dissent.

Some observers expect that Lee will gradually introduce a more flexible, inclusive approach to Singaporean society and politics. The motivation for this change comes from a belief that political opposition to the PAP will grow if the status quo is maintained. Also, the Government wishes to foster a more creative mindset in Singaporean society. Public policymakers argue that increased creativity will help achieve the country's long-term goal to become a service and knowledge-based economy. This transformation, in turn, is expected to ensure future prosperity.

(2) Investment Environment

Foreign investors are welcomed and enjoy transparent legal and regulatory systems and an efficient bureaucracy. No restrictions exist on foreign exchange transactions or the reinvestment or repatriation of earnings or capital. Singapore is considered virtually corruption free.

Singapore has signed several international dispute settlement and arbitration conventions. There have been no reports of significant disputes between the Government and foreign investors. Singapore has also been very active in pursuing free trade agreements. Seven agreements are in force and negotiations for an additional 14 treaties are underway with countries as diverse as Canada, India, Korea, Kuwait, and Panama.

In March 2007, Singapore became the first country to ratify a new international treaty on trademarks, created under the auspices of the World Intellectual Property Organization in 2006. This move highlights the stability of the country's in-

vestment environment and signals the Government's commitment to intellectual property rights.

(3) Political Violence

There have been no incidents of political violence for over 30 years. This record can be attributed to tough internal security laws, as well as to the substantial and consistent popularity of the PAP.

Singapore is becoming an increasingly important security presence in the Asia-Pacific Region. It now routinely trains all police and defense staff in counter-terrorism measures and has launched special units to handle maritime terrorist threats. The Government is very concerned that seaborne terrorist attacks will disrupt its ports, which are the busiest in the world.

Singapore also plans to make major military upgrades over the short term to further strengthen a defense force that is widely considered to be the most advanced in the Region. Singapore's security strategy is closely linked to that of the United States and, to a lesser degree, Australia and the United Kingdom.

Singapore's relations with its neighbors Malaysia and Indonesia can be strained at times as a result of territorial disputes or on issues related to water provision and critical infrastructure.

II/ PRIORITY HAZARDS/VULNERABILITIES

About 80 percent of Singapore's population live in high-rise buildings. Geographically, Singapore is located just outside the "Pacific Rim of Fire" and is thus spared from the destruction caused by natural phenomena such as earthquakes and volcanic eruptions. However, being highly urbanized, Singapore's main challenges are man-made and technology-based disasters. Examples of major incidents are the collapse of the six-story Hotel New World in 1986, the Southeast Asian haze event during 1997, and the SARS crisis in 2003.

According to the Singapore's National Assessment Report, Singapore's infrastructure includes one of the

world's busiest airports, the busiest seaport, and an extensive network of underground roadways. Land scarcity and high population density has made it necessary to house and locate populations and businesses in high-rise buildings. Mishaps thus have a greater potential to inflict mass casualties and extensive destruction to properties. There is also the threat of disasters that could potentially occur in the chemical and petrochemical industries located at the brink of the city. A major accident could have off-site impact on population centers. Urban terrorism is also emerging as a major threat to Singapore.

A. Built Environment

Singapore has well-developed design and construction standards (or codes) for buildings and other structures. The city also has a system of licensing of engineers and other specialists involved in the construction industry. It is therefore expected that all structures designed and constructed in Singapore conform to the safety standards specified in the codes and are consequently safe against various natural hazards.

Singapore is located just outside the “Pacific Rim of Fire” and is thus spared from the destruction caused by natural phenomena such as earthquakes and volcanic eruptions.

Singapore also has legal specifications to periodically inspect all old buildings to ensure their safety and habitability. This system ensures that the buildings do not deteriorate significantly after their construction and remain structurally sound. The city thus imposes high importance to the safety of the built environment to various natural hazards.

The safety of built environment is unlikely to be affected by the impacts of climate change, except those structures

along the coast that may be susceptible to seawater incursion.

B. Rainfall and Flooding

As an equatorial country, Singapore experiences rainfall around the year. As per the Singapore weather bureau, the city experiences rainfall in some parts on almost 300 days in a year. Singapore experiences episodes of intense rainfall, particularly during the north-east monsoon season (December to early March) and pre-southwest monsoon season (late March to May). If the episodes of intense rainfall coincide with high tide, then some parts of the city experience flash floods for short durations. Climate change may result in more frequent episodes of intense rainfall, and consequently more frequent flash floods. The increase in sea-level rise will also decrease the effectiveness of the drainage discharge systems and increase holding time resulting in more frequent floods.

III/ ADAPTATION MEASURES: ENHANCING RESILIENCE TO CLIMATE CHANGE IMPACTS

The Singapore Civil Defense Force (SCDF) is the primary agency responsible for disaster response in Singapore. The SCDF is an integration of typical fire department, emergency management, and civil defense. The SCDF is a uniformed organization headed by a Commissioner and under the purview of the Ministry of Home Affairs. Its main role is to provide fire fighting, rescue, and emergency ambulance services; as well as formulate, implement, and enforce regulations on fire safety and civil defense shelter matters.

The history of the SCDF can be traced back to 1888 when Singapore formed its first Fire Brigade. Some significant events in the history of the Singapore fire rescue operations include the Bukit Ho Swee Fire in 1961 and the Robinson's Fire in 1972. In 1980, the name of the Singapore Fire Brigade was changed to the Singapore Fire Service.

In 1982, the National Civil Defense Plan was launched. Then operating as a wing under the Singapore Police Force, the SCDF was formed to lead and spearhead emergency preparedness for the nation. With the enactment

of the Civil Defense Act in 1986, the SCDF was established as an independent organization under the Ministry of Home Affairs. In the same year, the Hotel New World collapse paved the way for joint operations between the SCDF and the Singapore Fire Service. Due to the similarity in roles and functions, the SCDF and Singapore Fire Service were formally integrated on April 15, 1989.

Today, the SCDF emergency preparedness program and disaster management activities are governed by three main laws: the Civil Defense Act of 1986, the Fire Safety Act 1993, and the Civil Defense Shelter Act of 1997.

The SCDF has setup an island-wide disaster management system to respond to various natural and man-made hazards. The main operation of the SCDF is through the following 4-pronged system:

- **Warning system.** The SCDF has installed an island-wide Public Warning System (PWS) which will be used to warn the public of military threats such as air raid. This system can also be used to alert the population of any serious industrial mishaps or natural disasters in localized areas. The warning given will enable the public to seek protection on time;
- **Protection system.** A comprehensive sheltering system has been planned to complement the PWS. The first phase of the shelter construction program covering high-rise public housing started in January 1987. This is in addition to the 9 underground MRT stations which have been hardened to serve as civil defense shelters. SCDF is responsible for the sheltering system and has raised national service units who will jointly manage the shelters with Civil Defense volunteers during emergency. Since 1997, all new public and private residential buildings must make provisions for a household or storey shelter;
- **Rescue system.** During peacetime, the Force is capable of handling more than one rescue operation and multiple fire incidents through its multi-fire station configuration. This capability will be upgraded to meet the wartime demands through the deployment of Civil Defense Na-

tional Servicemen who are organized and trained to undertake specialized operations. SCDF also co-operates with the various related agencies such as the Building Construction Authority, Public Utilities Board and the Singapore Police Force to restore normalcy as soon as possible;

The most critical impact of climate change for the SCDF is the likelihood of more frequent and recurrent flash floods during rains and high-tide. Since Singapore is an equatorial country and experiences rains almost around the year, the likelihood of flooding will also exist around the year. Climate change may require more frequent rescue calls to the SCDF from flash floods. In addition, the increase in temperature is also likely to increase incidences of fires that may also result in more frequent fire control and rescue requests; and

- **Command, control, and communication (C3) system.** The Force has an integrated computerized system that ensures the effective control of scarce resources and the deployment of forces to the most needed part of the island during emergency. The C3 system is equipped with state-of-the-art communication system and access to various required data. The C3 system is also integrated with video-surveillance cameras installed at critical locations to provide real-time information.

A. Clean Environment Strategy

Being a small city-state, Singapore has always focused on environmental sustainability as an important component of its development strategy. While several environmental threats have transboundary origins, there are several threats and impacts that can be addressed within the city. These constitute the main focus of Singapore Green Plan

All structures designed and constructed in Singapore conform to the safety standards specified in the codes and are consequently safe against various natural hazards.

2012 (SGP 2012). The SGP 2012 has also brought climate change to the forefront of national attention. Most components of SGP 2012 pertain to improving the environment quality of Singapore and are therefore directly relevant to the impact of climate change. Of these, 2 components focusing on air and water are of particular importance due to their sensitivity to climate change. The salient details of these components are described below:

(1) Clean Air

Singapore has focused on a four-pronged strategy of prevention, monitoring, enforcement, and education to manage air pollution. The salient points of the strategy are:

- **Prevention.** All new industrial proposals are referred to the National Environmental Agency (NEA) for evaluation at the planning stage to ensure that sufficient pollution control measures are in place from the start;
- **Monitoring.** Besides monitoring individual polluters, NEA also checks the ambient air quality for signs of pollution so that quick action may be taken to prevent any problem from escalating;
- **Enforcement.** Moving in step with the force of persuasion are a slew of enforcement action such as inspections on industrial and trade premises to ensure that environmental regulations are complied with; and
- **Education.** Greater awareness and a sense of ownership of the environment by the public will

The ASEAN Agreement on Transboundary Haze Pollution is the first such regional arrangement in the world that binds a group of contiguous states to tackle transboundary haze pollution resulting from land and forest fires.

lead to less pollution and reduce the need for enforcement.

Vehicle emissions are a major contributor to environmental pollution in Singapore and several measures have been taken to control their contribution. The most significant measures that have been adopted are as follows:

- Enforce stringent emission standards for the registration of all new vehicles;
- Require stringent standards on fuel used, such as diesel with low-sulfur content of 0.005 percent or less by weight, commonly known as ultra low sulfur diesel;
- Require all in-use vehicles to undergo mandatory periodic inspection and pass the smoke emission test;
- Carry out stringent enforcement actions against smoky vehicles on the roads; and
- Educate vehicle owners on proper vehicle maintenance to prevent smoke emissions.

The SGP 2012 has identified 3 major challenges to continue to enjoy clean air. The three are:

- **Particulate matter (PM) 2.5.** The United States Environmental Protection Agency (USEPA) set a strict limit for particulate matter: for the PM_{2.5} yardstick is 15 g/Nm³ and like many other major cities, Singapore reaching 21g/Nm³ has not met the USEPA standard for PM_{2.5};
- **Vulnerability to transboundary air pollution.** Singapore experienced intense transboundary haze that severely affected air quality in 1994 and 1997. In 1993, the Association of Southeast Asian Nations (ASEAN) members set up the ASEAN Specialized Meteorological Centre (ASMC) in Singapore. One of the key roles of the ASMC is to provide relevant weather information and forecast to ASEAN members so as to serve as an early warning to smoke haze over the ASEAN region. In addition, the ASEAN Agreement on Transboundary Haze Pollution is the first such regional arrangement in the world that binds a group of contiguous states to tackle transboundary haze pollution resulting from land and forest fires; and
- **Global climate change.** Although Singapore con-

tributes less than 1 percent of global greenhouse gas (GHG) emissions, it intends to be part of the global effort at ensuring environmental sustainability. Given its export-oriented economy and its limited capacity at exploiting renewable energy, there is a limit on what it can do on absolute carbon dioxide emissions. But it can improve on its carbon intensity. So far, its energy efficiency and clean energy efforts have improved its carbon intensity by 22 percent between 1990 and 2004. Singapore has committed to further improve this to 25 percent better than the 1990 level by 2012.

The 2006 revision of SGP 2012 recognized that climate change was not explicitly addressed in the original plan, and was included in the revised plan so as to bring the issue to the forefront of national attention. Since Singapore does not have sufficient scope to explore renewable sources of energy such as wind energy and hydroelectric energy that do not produce carbon emissions during electricity generation, the ability to cut absolute emissions in Singapore is limited. Hence, Singapore has recognized that it needs to play a meaningful role through its attempt at improving carbon intensity by seeking ways to use energy more efficiently.

(2) Clean Water

Singapore has scored a resounding success as far as diversifying its water supply sources goes. With its Four National Taps Strategy in full flow, it has enough water to meet its future needs:

- The first tap is the supply of water from local catchments. This consists of an integrated system of 14 reservoirs and an extensive drainage system to channel storm water into the reservoirs. The Marina Barrage, when completed in late 2007, will turn Marina Basin into Singapore's 15th reservoir with a catchment area of about 10,000 hectares (or one-sixth of Singapore's land area). Dams will also be constructed across Sungei Punggol and Sungei Serangoon and when completed in 2009, will create a new catchment area of over 5,000 hectares. Collectively, these projects will increase Singapore's water catchment areas from 50 percent to 67 per-

cent of Singapore's land area by 2009— fulfilling one of SGP 2012 targets on Clean Water;

- The second tap—imported water from Johor — supplements Singapore's needs;
- The third tap—NEWater or high-grade reclaimed water—also supplements Singapore's needs. Thanks to advanced membrane technologies, treated effluent from the water reclamation plants is processed to produce high-grade reclaimed water of drinkable quality. NEWater is supplied from three plants with a combined capacity of 21 million gallons per day. A fourth plant at Ulu Pandan, when completed at the end of 2006, will double the current supply; and
- The fourth tap—Desalinated Water—due to recent technological advances have made it an affordable source. The first desalination plant at Tuas started operations in September 2005 and can supply a maximum of 30 mgd of drinking water. This brings Singapore a step closer to meeting the SGP 2012 target of having non-conventional sources make up at least 25 percent of its water needs by 2012.

Following the success in the Four National Taps Strategy, Singapore has now adopted additional programs to ensure efficient, adequate and sustainable water supply. These include the following key thrusts.

(3) Water for All

Water quality management. The standard of potable water cannot be compromised. To ensure its high-quality, water will be monitored from source to tap through an Integrated Water Quality Management Plan. This includes putting in place a comprehensive water quality monitoring program, and special focus on water quality security, source control monitoring, and research and development (R&D) efforts on water quality.

Water quality management of catchments. Besides focusing on the quality of Singapore's water supply network, greater attention will be placed on activities upstream to ensure that its catchments are not polluted. The National Water Agency (PUB) has formed a surveillance team for more thorough checks on catchments

and waterways, and to educate the public, factory, and construction workers on proper practices to be adopted. Enforcement officers will also look out for the indiscriminate discharge of sullage/washing water from eateries, shop-houses, and landed properties into drains.

Control of trade effluent. Trade effluent from industries must adhere to prescribed standards before they can be discharged into a sewer or watercourse. Regular surveillance is carried out to check for compliance with pollution control requirements and discharge standards. The revised trade effluent standards came into force on May 1, 2005, for new industries, although existing industries were given a two-year grace period to comply.

Erosion and sediment control measures. The Brown to Clear (B2C) Program addresses the problem of silt pollution in watercourses as a result of storm-water runoff from construction sites. Under this program, the Government of Singapore is working with the construction industry to raise awareness among its members and also get them to adopt Earth Control Measures at worksites to reduce the silt discharges into the watercourses.

(4) Conservation of Water

Domestic sector. The mandatory installation of low-capacity flushing cisterns in new premises including HDB flats, Main Upgrading Program MUP flats, and premises undergoing renovations since the 1990s has helped reduce the domestic water consumption. Low-capacity flushing cisterns use about 3.5 to 4.5 liters per flush compared to 9 liters in normal cisterns. In addition, it intends to look into the feasibility of making it compulsory for all premises to install dual-flush low capacity flushing cisterns by 2009.

The Brown to Clear (B2C) Program addresses the problem of silt pollution in watercourses as a result of storm-water runoff from construction sites.

Non-domestic sector. The construction industry accounts for a significant 6 percent of the total non-domestic water consumption. Currently, construction site owners must ensure that the flow rates of the water fittings within the construction sites comply with PUB standards. Singapore also plans to encourage the industry to use NEWater as an alternative to potable water where possible.

(5) Value of Water

The Government alone cannot keep the waterways and catchments clean. It needs the co-operation of the community. The Government intends to encourage a change in water usage habits from the community and educate them on the implications of living in water catchment areas. The “value our water” message will be disseminated to the community through publicity materials and the mass media. In schools, the young will learn how to care for the water resources via the school curriculum, the schools’ cleanup programs, and excursions to facilities such as the NEWater Visitor Centre. The foreign workforce will not be left out, and the Government of Singapore will work with Ministry of M, maid agencies, and industry associations to impart proper water usage to the workers.

(6) Enjoyment of Water

Now that more recreational and sporting activities are taking place in reservoirs and waterways, it is imperative that users recognize the importance of keeping them clean. Thus, a Code of Conduct on the proper use of these water bodies will be introduced. The tagline, “Water for All: Conserve, Value, Enjoy” will also be highlighted on publicity materials of all events held at reservoirs.

B. National Energy Policy

Singapore has long focused on energy efficiency and energy use as a part of its national policy due to its high energy demand and the absence of petrochemical resources. The national energy policy has recently been greatly expanded and strengthened to address energy dependence, foreign policy, and climate change in an integrated manner. The energy policy has also incorporated the requirements of sustainable development and the need to continue to grow at a healthy rate.

The key elements of the national energy policy have been excerpted below to bring out the key issues and illustrate its integration into national policy while considering the requirements of sustainable development.

(1) Changing Energy Landscape

The global energy landscape has changed since the turn of the century. First, the trend of higher oil prices, especially in recent years, is expected to persist over the medium to long term, driven by both demand and supply factors. An expanding world population and strong economic growth, especially in large emerging economies like China and India, are fuelling the demand for energy.

On the supply side, there are sufficient reserves of oil, natural gas, and coal to meet global energy needs for the next few decades. However, whether new supplies will come on-stream depends on producer countries making timely and sufficient investments to increase output. Geopolitical tensions and natural disasters could also disrupt supplies, driving prices higher and increasing price volatility. Given that the Middle East holds the bulk of the world's proven oil and gas reserves, the world's dependency on this region for energy will also increase.

Singapore is dependent on oil and natural gas imports for its energy needs. It is vulnerable to a number of supply risks, including under-investment in energy production by energy exporters, and events such as geopolitical conflicts that may disrupt supply. Its economic growth can also be undermined by rising energy prices.

Secondly, climate change has emerged as one of the world's biggest environmental challenges. There is scientific consensus that climate change is very likely caused by the increase in GHG emissions from human activities, the chief of which is the release of carbon dioxide (CO₂) from the burning of fossil fuels. Warmer temperatures can result in rising sea levels and more extreme weather events.

As a relatively low-lying, small island state in the tropics, Singapore is not spared from the effects of climate change. However, Singapore's domestic energy demand

is small, and it accounts for just 0.15 percent of the world's CO₂ emissions. Much of the energy consumption is used to produce and deliver goods and services to the rest of the world. Singapore's own efforts to mitigate emissions will not have much impact on climate change unless carried out as part of a concerted global effort. Nonetheless, as a responsible citizen of the international community, Singapore will play its part in mitigating climate change, through enhancing energy efficiency and developing clean energy technologies and solutions.

A national energy policy framework which strives to maintain a balance between the policy objectives of economic competitiveness, energy security, and environmental sustainability.

(2) National Energy Policy Framework

Moving forward, the inter-agency Energy Policy Group chaired by the Permanent Secretary of the Ministry of Trade and Industry has developed a national energy policy framework which strives to maintain a balance between the policy objectives of economic competitiveness, energy security, and environmental sustainability. To meet Singapore's objective of continued economic growth while safeguarding their energy security and natural environment, the focus will be on the following six key strategies:

- **Strategy 1, Promote competitive markets.** Singapore is committed to the promotion of competitive markets. This will help keep energy affordable and ensure its economic competitiveness. Singapore has liberalized its electricity and gas markets, and is looking into enabling full contestability in the electricity retail market. Where there are market failures, Singapore will correct them by using market-based instruments or im-

posing standards and regulations. Singapore will also encourage the private sector to innovate and achieve the energy security and environmental outcomes that it is seeking;

- **Strategy 2, Diversify energy supplies.** Energy diversification will help to protect Singapore against supply disruptions, price increases, and other threats to the reliability of supply. In competitive markets, companies themselves will have the incentives to diversify, and reduce their own commercial risks. The Government's role is to create an open and flexible framework that allows diversification to take place. For Singapore, there are also practical challenges to fuel diversification due to its limited energy options. Hydro, geothermal, and wind power are not available in Singapore, while nuclear energy is not feasible due to the country's small size. Solar and coal power have some potential, but they face cost and technological barriers, and environmental concerns respectively. Nonetheless, Singapore should not write off any energy option for the country. As technology improves, energy sources that are not viable for Singapore today may become feasible options in the future;
- **Strategy 3, Improve energy efficiency.** Improving energy efficiency is a key strategy as it can help to achieve all 3 objectives of the country's energy policy. Using less energy to obtain the same output will decrease Singapore's dependence on energy imports and enhance its energy security, while reducing business costs, pollution, and CO₂ emissions. The Government has set up an Energy Efficiency Program Office (E2PO) and developed a comprehensive national energy efficiency plan called Energy Efficient Singapore (E2 Singapore);
- **Strategy 4, Build energy industry and invest in energy R&D.** Singapore can turn the energy challenges into opportunities by positioning its economy to meet rising global and regional demand for energy. Singapore intends to increase its refining capacity to consolidate its status as Asia's premier oil hub. Singapore will expand the range of energy trading products to include liquefied natural gas (LNG), bio fuels, and carbon emission

credits. Singapore is also pursuing growth opportunities in clean and renewable energy, including solar energy, bio fuels, and fuel cells. Strong R&D capabilities are required to support industry development in these areas, which will also enable Singapore to develop solutions that address its own energy needs;

- **Strategy 5, Step up international cooperation.** Given Singapore's small size and reliance on energy imports, it is important that its energy policy includes efforts to promote greater regional and international energy cooperation to further its energy interests. To enhance its energy security, Singapore continues to be actively involved in various energy-related initiatives in major fora, including the Association of Southeast Asian Nations (ASEAN), the Asia-Pacific Economic Cooperation (APEC), and the East Asia Summit (EAS). Because effective action against climate change needs to be carried out at an international level, Singapore also participates actively in the United Nations Framework Convention on Climate Change (UNFCCC), as well as international discussions on climate change in other fora; and
- **Strategy 6, Develop whole-of-government approach.** The growing complexity and strategic importance of energy policy demands a whole-of-government approach. The work of drawing together the different strands of Singapore's energy policy began with the formation of the Energy Policy Group in March 2006. The Energy Policy Group plays the role of formulating and coordinating Singapore's energy policies and strategies. In addition to the development of a national energy policy framework comprising the 6 strategies outlined, the Energy Policy Group studied a wide range of energy issues which include power and transport sectors, energy efficiency, climate change, energy industry, energy R&D, and engaging international energy partners.

Several organizational changes have also taken place, such as the creation of a new Energy Division in the Ministry of Trade and Industry, the expansion of the Energy Market Authority, and the creation of the Clean Energy Pro-

gram Office and the E2PO. The Government has also set up the Energy Studies Institute at the National University of Singapore to promote and develop policy-oriented research on the economic, environmental, and international relations aspects of energy, as well as contribute to energy dialogue and collaboration within the region.

(3) Power Sector

Competitively priced and reliable electricity supplies are critical for Singapore's economy. The Government of Singapore has restructured and liberalized the electricity and gas markets. Market competition and the fuel switch from oil to gas have improved the competitiveness of electricity prices, reduced air pollution, and lowered its CO₂ intensity. Going forward, the challenge for the power sector is to continue to deliver secure and affordable electricity supplies to meet rising demand as the city's economy and population grow.

Singapore's fuel mix is much less diversified compared to the global average. About 76 percent of the electricity is generated from piped natural gas transported from Malaysia and Indonesia. To diversify its energy sources, Singapore is planning to import LNG by 2012. There is value in promoting a more diverse energy system to reduce the vulnerability to supply and price risks. Given the rapidly evolving nature of energy markets and technologies, the private sector is best placed to decide on which technologies and fuels to invest in that will meet the needs of consumers. This is preferable to the approach whereby the Government prescribes a top-down fuel mix. The role of the Government is to ensure that its policies are open and flexible enough to enable energy diversification by the private sector. The Government of Singapore will also facilitate the introduction of promising new technologies by supporting R&D, test-bedding, and demonstration of new technologies, and facilitating and reducing the cost of grid connection.

While ensuring that electricity supplies remain affordable, Singapore should not subsidize energy consumption as this will distort markets and lower incentives for users to conserve energy. Instead, it will promote competitive energy markets to improve efficiency, encourage innovation, and drive down prices. To implement full retail contestability, the Energy Market Authority is

piloting the Electricity Vending System that will allow retail consumers to choose their electricity retailers. Incorporating smart metering technologies, the Electricity Vending System will enable consumers to monitor their electricity consumption and reduce their electricity bill through prudent use of electricity.

(4) Transport Sector

An efficient and cost effective transport sector is crucial to Singapore's economic competitiveness and its quality of life. Besides having a high-quality and efficient land transport system, Singapore is also a major international aviation and maritime center.

For land transport, the city's strategies of promoting the use of public transport and innovative policies to restrain car ownership and usage will help to address the energy challenges by encouraging energy efficiency and conservation. To safeguard public health and the environment, the city has also put in place policies such as mandatory vehicle inspections, vehicular emission standards, and promotion of fuel efficient and green vehicles.

A key transport target is to achieve a public transport modal split of 70 percent in the morning peak period by 2020, up from the current 63 percent. To improve fuel efficiency of vehicles, the Government is considering introducing mandatory fuel economy labeling, in addition to increasing public awareness of fuel efficient driving habits.

For air and sea transport, the Government is supportive of global efforts to reduce the impact of emissions on the environment. Thus, Singapore actively participates in the work of the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) in addressing the environmental impact of international air and sea transport.

Looking ahead, oil is likely to maintain its dominant role in powering Singapore's vehicles, aircrafts, and ships, but there could also be opportunities for the entry of alternative, cost competitive fuels as technology improves. Where necessary, the Government will look into the setting of relevant standards to assist in the adoption of new fuels and technologies. Singapore will also continue to

facilitate R&D on alternative fuels and technologies that can enhance energy diversity, improve energy efficiency, and reduce emissions.

(5) Energy Efficiency

While energy efficiency often makes economic sense, energy efficiency measures are sometimes not implemented due to market imperfections such as a lack of information and higher upfront costs. To improve energy efficiency in Singapore, the Government has established the inter-agency E2PO led by the National Environment Agency. The E2PO has developed a comprehensive national plan on energy efficiency for Singapore known as “Energy Efficient Singapore” or “E2 Singapore”. E2 Singapore includes promoting the adoption of energy efficient technology and measures, building capability and expertise in energy management, public education to promote energy efficient behavior, and R&D in energy efficiency technologies

The E2PO will primarily adopt a sectoral approach targeted at the power generation, industry, transport, building, and household sectors. The ongoing and planned programs to promote energy efficiency include the following:

- **Power generation.** Between 2000 and 2006, overall power generation efficiency improved from 38 percent to 44 percent due to the switch to oil-fired steam plants to combined cycle gas turbines. The E2PO will also continue to promote cogeneration and tri-generation through, for example, integrating the deployment of these facili-

ties into ongoing and future industrial planning;

- **Industry.** The Energy Efficiency Improvement Assistance Scheme co-funds up to 50 percent of the cost of energy appraisals for buildings and industrial facilities. Under the Investment Allowance Scheme, capital expenditure that results in more efficient energy utilization can be granted a capital allowance that allows a deduction against chargeable income. Programs will be developed to help companies incorporate efficiency considerations early on in the conceptual design phase of a new facility;
- **Transport.** To further increase the energy efficiency of Singapore’s land transport system, the Government will focus on encouraging greater use of public transport, promoting use of more fuel efficient vehicles, and reducing congestion on its roads. Policies under consideration include mandating fuel economy labeling and efforts to increase public awareness of fuel-efficient driving habits;
- **Buildings.** Building control regulations help reduce the energy required for cooling, while the Green Mark and EnergySmart schemes help spur developers to build energy efficient buildings. From 2008 onwards, all new buildings and existing buildings undergoing major retrofitting works with gross floor area above 2,000 square meters must meet the Green Mark Certified standard. The Government has also launched the Green Mark Incentive Scheme to encourage building developers to achieve higher Green Mark ratings; and
- **Households.** Singapore will continue to encourage consumers to purchase energy efficient appliances and to adopt energy saving habits. New initiatives include mandatory energy labeling for all household refrigerators and air-conditioners sold in Singapore, and encouraging households to reduce standby power consumption.

Singapore formulated a National Climate Change Strategy in 2007 that lays out ongoing measures and future plans in the area of adapting to climate change and in mitigating CO₂ emissions.

(6) Energy and the Environment

The production, transmission, and consumption of energy have an impact on the environment, in terms of localized health impact due to air pollutants and long-term, wide-ranging climate change impact due to GHG emissions.

Singapore formulated a National Climate Change Strategy in 2007 that lays out ongoing measures and future plans in the area of adapting to climate change and in mitigating CO₂ emissions. The National Climate Change Committee led by the Ministry of the Environment and Water Resources also provides an avenue to engage and gather feedback on climate change and energy efficiency from the public, private, and people sectors.

To better understand the potential impact of climate change on Singapore over the next century, the NEA has commissioned a climate change vulnerability study that is scheduled for completion in 2009. The findings will enable it to design a robust long-term adaptation response to climate change. However, Singapore has devised and implemented several mitigation initiatives in the meantime since these initiatives are directly linked to more efficient energy utilization and cleaner environment.

To mitigate Singapore's GHG emissions, the two key measures are to use less carbon-intensive fuels and to improve its energy efficiency. Singapore's ambient air quality compares well to major cities in industrialized countries for most pollutants except particulate matter. Diesel vehicles account for about 50 percent of the PM_{2.5} emissions in Singapore. Apart from compulsory periodic inspections, Singapore has adopted Euro IV standards for new diesel vehicles in October 2006. In addition, it will continue to promote the use of green vehicles such as petrol-electric hybrid vehicles and compressed natural gas (CNG) vehicles.

Singapore also needs to continue to deal with sulfur dioxide (SO₂) emissions from power plants and its oil refining industry. The power generation sector (power plants using oil) and industries account for about 99 percent of SO₂ emissions and 30 percent of PM_{2.5} emissions. To reduce the levels of these pollutants, Singapore has implemented emission concentration limits for various air pollutants, an overall emission cap for SO₂ and limited the sulfur content of fuels.

(7) Energy Industry

The energy industry is a major contributor to the Singapore economy. Singapore envisages that while the oil industry

will continue to play a key role, there are exciting new opportunities in areas such as solar power, fuel cells, biofuels, and energy management solutions. Singapore's goal is to increase the value added of Singapore's energy industry from \$20 billion to around \$34 billion by 2015, and to triple the employment generated from 5,700 to 15,300.

Emission credits and biofuels are also included as qualifying products under the Global Trader Program.

Several developmental strategies to expand the energy industry have been adopted as described below:

- **Expand refining base.** Due to strong demand for oil in Asia, there is considerable upside for Singapore to grow its refining capacity from its present 1.3 million barrels per day. Singapore intends to do this by promoting the expansion and upgrading of its existing refineries and attracting greenfield investments. This will help maintain its share of global refining capacity, and create the liquidity needed to anchor oil trading and price discovery activities in Singapore;
- **Expand beyond oil trading to energy trading.** Singapore intends to leverage on its experience in oil trading and expand the range of energy products priced and traded in Singapore to include LNG, carbon emission credits and biofuels. Since May 2007, Singapore has introduced a concessionary tax rate of 5 percent on LNG trading income for companies under the Global Trader Program. Emission credits and biofuels are also included as qualifying products under the Global Trader Program;
- **Grow clean energy sector.** The global market for clean energy technologies is expected to experience tremendous expansion in the next decade as a result of greater concern for climate change. Singapore views clean energy as a key growth

area. Its experience and capabilities in the semiconductor, industrial equipment, and chemicals sectors puts Singapore in good stead to capture opportunities in the solar, fuel cells, and biofuels markets. Creating a conducive environment for technological innovation and R&D will also be essential for the growth of this sector; and

- **Help sustainable energy providers expand regionally.** Rapid urbanization and increasing awareness of climate change issues in Asia will lead to greater demand for sustainable energy solutions that are applicable to urban environments. Singapore intends to capitalize on market opportunities in areas such as intelligent grid management through growing a pool of energy services companies that can export their expertise on energy efficiency and conservation.

(8) Energy R&D

New energy technologies can help make Singapore energy system more efficient, cleaner, and more diversified. Singapore's research institutes, universities, and private sector are already engaging in various energy-related R&D activities. For instance, the Agency for Science, Technology and Research (A*STAR), the National University of Singapore, and the Nanyang Technological University are developing novel materials for solar cells. Another example is Vestas, the world's largest supplier of wind power systems, which is setting up a \$500 million R&D center in Singapore.

Moving forward, Singapore intends to intensify its energy R&D efforts in areas where it has expertise or competitive advantage. One key new initiative is the Singapore Initiative in New Energy Technologies (SINERGY), which will provide technical infrastructure, such as a microgrid and command and control facility, to facilitate research on clean and sustainable energy solutions. SINERGY will also develop in-house expertise in systems integration, testing, and evaluation of energy technologies.

In addition, A*STAR has established an Energy Technology R&D Program to integrate and expand existing knowledge, as well as work on fuel cells, alternative fuels, and next-generation solar technologies. In August 2007,

the Economic Development Board launched the Clean Energy Research and Test-bedding Program, which will provide S\$17 million in funding to promote the application of clean energy technologies to public sector facilities. The National Research Foundation has also set aside S\$170 million to boost Singapore's clean energy R&D efforts, starting with a focus on solar technologies and fuel cells.

(9) Engaging International Energy Partners

There are three-fold objectives of engaging the external energy partners as described below:

- **To promote regional and international energy cooperation to further Singapore's energy interest.**

On a bilateral level, Singapore will continue to develop relations and enhance cooperation with key energy players such as energy producing countries and industry majors. On the multilateral level, Singapore participates actively in regional and international forums, including ASEAN, East Asia Summit, and APEC, to promote various initiatives such as energy market integration, energy efficiency, and renewable energy. Singapore also supports and actively participates in climate change initiatives both within the UNFCCC framework and at other fora. The Government has set up a Ministerial Committee on Climate Change chaired by Deputy Prime Minister Professor S. Jayakumar to coordinate these efforts. Although Singapore is a small country, it has been finding innovative ways to contribute meaningfully, such as sharing its experience in water and waste management, and sustainable city planning. Concerns over energy security and climate change have also resulted in a re-emergence of nuclear energy as an important alternative energy source. In this regard, Singapore is working with various partners to create the environment to encourage the development of safe and secure nuclear energy for civilian use;

- **To promote security of vital energy sear lanes in the region.**

For Singapore and East Asia, the Straits of Malacca and Singapore is an integral part of the criti-

cal energy supply route from the Middle East to East and Southeast Asia. The security of transit along the Straits is critical to the energy security of Singapore and the region. The littoral states of Indonesia, Malaysia, and Singapore participate in a range of initiatives to ensure safe transit passage and the freedom of navigation through the Straits. The establishment of the Cooperative Mechanism in September 2007 will further facilitate cooperation on navigational safety and environmental protection between user and littoral states in the Straits of Malacca and Singapore; and

- **To promote Singapore as a center of energy research and excellence.**

Singapore recognizes the need to develop expertise and capabilities on energy-related issues and to keep abreast of global developments in this area. The establishment of the Energy Studies Institute will support this objective by promoting greater awareness, dialogue, and collaboration within the region through policy-oriented research and organizing activities such as conferences and seminars. Singapore will also strengthen its collaboration with various research institutes on energy R&D through agencies such as the National Research Foundation and A*STAR.

(10) Looking Ahead

The Energy for Growth program outlines Singapore's national energy policy framework and strategies with the aim of achieving economic competitiveness, energy security, and environmental sustainability. Singapore aims to continuously monitor and understand developments in the evolving global energy landscape, and be ready to fine tune existing policies and formulate new strategies when needed to keep Singapore ahead in the energy arena and to support its continued economic growth.

The global energy landscape is ever evolving. With rising energy prices, energy security has become a key concern to many countries, including Singapore. In addition, climate change has emerged as one of the biggest environmental challenges the world is facing today. Singapore intends to address both these challenges and capitalize on the opportunities generated by the changing global energy landscape to sustain its long-term economic growth.

IV/ MITIGATION MEASURES

Singapore intends to meet its national carbon intensity target through actions in each of five broad sectors that contribute to energy use in Singapore as described above. The strategies and actions under each sector take into account the different underlying factors and constraints faced by each sector, although all sectors would contribute to achievement of the national carbon intensity target. The details each of the five sectors are discussed below:

A. Carbon Intensity Targets in 5 Sectors

(1) Power Generation Sector

The power generation sector is the single largest primary source of CO₂ emissions in Singapore, accounting for about 50 percent of its carbon emissions in 2004. The electricity generated is then consumed by secondary users such as industries, commercial buildings, and residential homes. As the single largest sector in terms of source emissions, power generation companies or gencos can thus play a significant role in contributing toward meeting Singapore's climate change goals.

The strategy for power generation is to improve its efficiency as well as to encourage the move toward cleaner and less carbon-intensive fuels (e.g., natural gas, renewable energy) while keeping in mind the need to keep electricity costs affordable.

It is worthwhile to note that in meeting its energy demand, Singapore has always made a conscious effort to safeguard environmental interests. This was one of the reasons why conventional coal, with its environmental impacts, was never encouraged for power generation.

Cleaner fuels

In recent years, Singapore has made significant progress in the power generation sector to make it even cleaner. The electricity market was liberalized in 2001, thus introducing competition among the gencos. This created incentives for gencos to use the most efficient technology for power generation and created a market in which environmental interests are aligned with economic inter-

Primer — City Profile

ests. Investments were also made in natural gas pipeline infrastructure. These measures have facilitated a significant switch from burning fuel oil to natural gas for power. Within just 5 years, the proportion of electricity generated by gas in Singapore has grown from 19 percent in 2000 to 74 percent in 2005, one of the highest levels in the world. This has led to significantly lower CO₂ emissions from the power sector, as natural gas emits 40 percent less CO₂ than fuel oil per unit of electricity generated.

Energy-efficient generation technology

At the same time, the adoption of more efficient technologies such as combined-cycle gas turbines in gas-fired power plants has improved Singapore's overall generation efficiency from 37 percent in 2000 to 44 percent in 2004, reducing its CO₂ emissions even further. The rise in overall generation efficiency during the last few years is given in Table 1 indicating the impact of the mitigation strategies on power generation sector.

Waste-to-energy

Singapore is also one of the few countries that incinerates all of its combustible waste and recovers energy through the process. Since 2000, its waste-to-energy plants have contributed up to two percent of its energy supply. Thus, unlike other countries, Singapore produces negligible amounts of methane from landfills.

Renewable energy

In terms of renewable energy, solar energy offers the greatest potential in Singapore. However, the cost of generating solar energy through photovoltaic cells is still much higher than conventional grid electricity, and Singapore has been involved in renewable energy research to increase the yield and lower the cost.

The NEA encourages private and public sector partners to explore and test-bed new technologies (e.g., solar energy, fuel cell) through schemes such as the Innovation

for Environmental Sustainability Fund, which co-funds innovative environmental projects and the Environmental Test-bedding Initiative, which allows access to public infrastructure for test-bedding purposes. For instance, NEA, together with EDB and Energy Market Authority, facilitated the installation of a 14.5 kilowatt-peak (kWp) grid-connected photovoltaic system at the German European School in Singapore.

CO₂ emissions standards for power plants (proposed)

Singapore's strict emissions standards for power plants and other industrial emitters have helped to keep air pollution levels in Singapore low. With rising fuel oil and natural gas prices, there has been growing interest in the use of other fuels such as coal for power generation. However, they generate large volumes of CO₂ emissions as well as other environmental by-products such as ash and particulate matter.

To balance the potential changes in fuel sources with environmental concerns, Singapore plans to introduce CO₂ emissions standards for new power plants that will limit the CO₂ emissions of such plants to the level of existing fuel-oil firing plants. This maintains its environmental quality while causing minimal disruption to the power generation industry. These standards will be subject to review as technology progresses.

Corporate reporting of CO₂ inventory (proposed)

Environmental reporting encourages proper disclosure of a company's environmental performance and promotes transparency of corporate decisions where they may impact the environment. Managing and reporting for environmental performance is increasingly important to reduce costs, improve processes, and meet stakeholder expectations, particularly in a high fuel price environment. It is thus an important part of the corporate social responsibility movement in many countries.⁵ In Sin-

TABLE 1. Electricity generated by natural gas and overall generation efficiency

	Percentage					
	2000	2001	2002	2003	2004	2005
Electricity generated by natural gas	19	29	44	60	69	74
Overall generation efficiency	37	38	39	41	45	44

gapore, companies and institutions such as Singapore Airlines; ST Microelectronics, Sony Electronics; City Developments, Ltd.; and Singapore Polytechnic already issue environmental reports.

In view of the environmental challenge posed by climate change, the Government plans to encourage corporate reporting of CO₂ emissions among its gencons, as well as among large energy-using companies, to raise awareness of their energy usage and thereafter to help them identify areas for efficiency improvement.

(2) Industry Sector

The industry sector accounted for about 54 percent of Singapore's CO₂ emissions in 2004 through primary combustion of fuels for industrial processes (33 percent) and secondary consumption of electricity (21 percent). Singapore's approach toward industries is a "win-win" situation. It acknowledges that industries in Singapore produce largely for international markets. Therefore, regulations that are too tight may create compliance costs that force industries to relocate elsewhere, leaving an adverse impact on the Singaporean economy without a significant reduction in global GHG emissions. Therefore, Singapore aims to focus on improving the energy efficiency of its industries, which not only lowers their carbon intensity but renders them more cost-competitive in the current high oil price environment.

The global concern with climate change also brings with it new business opportunities, such as the export of carbon-efficient technologies to support the sustainable development aspirations of other developing countries and the provision of carbon services such as emissions trading. These opportunities match Singapore's environmental, engineering, and financial expertise, and it will engage local industries to seek out such opportunities.

New business opportunities, such as the export of carbon-efficient technologies.

This would contribute to global efforts in mitigating climate change. The business opportunities related to climate change are described later in the Profile.

The most significant achievements and future plans in the industry sector are described below.

Grants for energy audits

In July 2002, the then National Energy Efficiency Committee launched an Energy Audit Scheme for major industrial consumers of energy, such as oil refineries and petrochemical plants. To date, six major facilities from the petroleum refining and petrochemicals industries, which account for about 20 percent of Singapore's emissions, have voluntarily signed up to the Scheme, committing to carry out energy audits in their premises and formulate action plans to improve their energy efficiency over a period of five to seven years.

In April 2005, Ministry of the Environment and Water Resources and NEA launched the \$10 million Energy Efficiency Improvement Assistance Scheme to co-fund energy audits for large energy consumers (i.e., manufacturing companies as well as building owners and operators). The objective of the Energy Efficiency Improvement Assistance Scheme is to spur these consumers to improve the energy efficiency of their facilities by engaging energy service companies to carry out energy audits and identify areas for improvement. As of May 8, 2006, a total of 18 applications from manufacturing companies (10) and building owners/operators (eight) have been approved, with total anticipated energy savings of about \$7 million annually, equivalent to about 54 kilo-tons (kt) of CO₂ mitigated annually.

Tax incentives for energy efficient equipment

Singapore also has an Accelerated Depreciation Allowance Scheme that allows companies to fully depreciate the capital expenditure energy efficient equipment over 1 year instead of the usual 3. This scheme encourages companies to replace old, energy-consuming equipment with more energy efficient ones and to invest in energy-saving equipment.

Cogeneration (proposed)

Cogeneration, or combined heat and power, is an efficient

method of generating both heat and electricity in an integrated process, and is applicable in instances where both electricity and heat are required. By making use of the waste heat generated in the combustion process, cogeneration can increase the energy efficiency of power generation from about 40–50 percent to more than 75 percent. While cogeneration is a technology more commonly used in industrial facilities, it can also be extended to buildings in general. Cogeneration or even tri-generation (combined heat, power, and chilled water generation) is currently used and test-bedded in some facilities in Singapore, and the city is looking into ways to increase its use.

Energy-efficient industrial equipment (proposed)

General industrial equipment such as motors, boilers, chillers, and compressors account for a large amount of the energy used by industries. For instance, motors consumed 24 percent of all electricity in the European Union in 2000.

In order to help its industries use energy-efficient equipment, Singapore plans to consider the following:

- (a) Providing more tax incentives for industries to switch to more efficient equipment;
- (b) Setting minimum energy efficiency standards for energy-intensive industrial equipment used in Singapore. Other countries have done so for equipment such as motors, boilers, air-conditioners, lamps, ballasts, and chillers; and

By making use of the waste heat generated in the combustion process, cogeneration can increase the energy efficiency of power generation from about 40–50 percent to more than 75 percent.

- (c) Exploring energy labeling for energy-intensive industrial equipment used in Singapore. Other countries have done so for equipment such as boilers, lamps and ballasts.

Energy audits and best practices (proposed)

The identification of ways to significantly reduce energy consumption can be best done through the commissioning of energy audits that can take into account the specific energy needs of each industrial facility or plant. Reducing energy consumption not only reduces GHG emissions, it also helps to reduce operating costs. The Government of Singapore plans to step up efforts to profile facilities that have undergone energy audits and their success stories, and encourage greater take-up of the Energy Efficiency Improvement Assistance Scheme by industries and buildings, in particular the heavy energy users.

(3) Transport Sector

The transport sector in Singapore accounted for 19 percent of the emissions in Singapore in 2004. There were 727,395 vehicles on the road in 2004, an 18.9 percent increase from 10 years earlier, with numbers of passenger cars rising faster than other vehicle types. Singapore aims to meet the mobility needs of Singaporeans while minimizing the amount of greenhouse gases and air pollutants emitted.

Given the rising car population in Singapore, managing the emissions from transport is best achieved through the following three-part strategy:

- (a) Managing vehicular usage;
- (b) Improving fuel efficiency of vehicles; and
- (c) Promoting use of cleaner fuels and green vehicles.

(4) Building Sector

Energy use in buildings made up 16 percent of Singapore's energy demand in 2004. Given Singapore's tropical climate, it is not surprising that need for air-conditioning forms a large part of its electrical demand. It can be expected that rising temperatures due to climate change will further increase the demand for cooling. Indeed, most commercial and institutional energy usage comes from air-conditioning and lighting.

The strategy for the buildings sector is to promote energy-efficient design of buildings, energy-efficient technologies, and energy conservation practices.

Buildings can be designed to encourage greater use of natural light and ventilation. Proper insulation also ensures that less energy is used to cool down buildings. Studies have shown that energy-efficient buildings can reduce energy use by 35 percent. Beyond improving energy efficiency, energy conservation measures can also help reduce energy demand. While Singapore will not restrict the uses of energy in buildings, it aims to promote habits that prevent wastage of energy, such as turning off the lights and appliances when not in use.

(5) Households Sector

Energy used by households forms 9 percent of the energy used in Singapore in 2004. Indeed, the average Singaporean household spends \$107 a month on electricity bills. On average, a household living in a 4-room HDB flat uses 392 kilowatt-hour of electricity a month, while a household living in a private apartment uses about 725 kilowatt-hour of electricity a month. Breaking that amount down, a typical 4-room air-conditioned HDB flat spends 30 percent of its energy bills on air-conditioning, 17 percent on its refrigerator, 10 percent on lighting, and nine percent on its water heater.

Singapore plans to work toward improving its carbon intensity in the household sector such that as its standard of living rises, the energy use does not rise correspondingly. This will be done by targeting purchase decisions to encourage the choice of energy-efficient appliances, as well as by encouraging households to adopt energy-efficient habits.

As Singapore becomes more affluent, households make greater use of energy-intensive appliances such as air-conditioners. Indeed, electricity consumption in the domestic sector has grown faster than any other sector since 1992.

Energy-efficient appliances and lights allow end-users of electricity to maintain or improve their quality of life while reducing energy consumption. Singapore plans to

Studies have shown that energy-efficient buildings can reduce energy use by 35 percent.

improve the information available to households to help make informed choices, for instance through improving energy-efficiency labeling. At the same time, it will create public awareness of energy conservation habits, to allow people to reduce energy consumption and thus lower their energy bills while maintaining their quality of life.

B. Competency Building for Climate Change

The Singapore Government is committed to reducing its GHG emissions in both the short and longer term. To achieve this, it needs to continue to develop a broad range of competencies to help it achieve its climate change goals.

(1) Research and Development into Low-carbon Technology

Technology will play a crucial role in Singapore's ability to address climate change adequately in the long term. Research into renewable energy will decrease its reliance on carbon-intensive fossil fuels, while developing energy-efficient technology and carbon sequestration techniques will reduce the impact of its growing energy needs. Similarly, new adaptation technology will help it address its vulnerabilities to climate change.

The objective of research is not only to improve the current state of technology, but also to bring down production costs to a level that would make large-scale adoption commercially viable. In Singapore's context, the focus in the nearer term would be on energy efficiency technology as well as on solar photo voltaic and biofuels, both abundant energy sources in the region. Singapore will also continue to promote R&D in fuel-cells, both for micro-generation and transportation use.

(2) Growth in Environmental Industry

The environment industry is estimated to be worth about

US\$600 billion globally and has been identified by EDB as a new strategic growth area for Singapore. There are plans to increase the economic contribution from the environmental industry from 0.6 percent to 1.5 percent of its GDP, and to provide 35,000 jobs in 2015 up from 20,000 jobs in 2003.

A key contributor to this growth will be the alternative energy industry. Alternative energy technologies such as solar power and biofuels will be instrumental not just in Singapore's domestic efforts to address climate change but also in global efforts as demand for renewable energy increases worldwide. Singapore's capabilities in engineering and environmental technology make it an attractive center for the production of alternative energy products. Already it has attracted some investments in solar and biodiesel. These climate-friendly technological solutions if used in other countries can contribute to the global effort to address climate change.

Reciprocally, global commitment to climate change would create a greater demand for renewable energy and energy services, thus contributing to the development of this emerging industry and its overall economic growth.

C. New Economic Opportunities through Harnessing Market Forces

Under the Kyoto Protocol, Annex I parties (largely industrialized countries such as the European states, Japan, and Canada) are obligated to reduce their GHG emissions by an average of 5.2 percent below their 1990 levels from 2008 to 2012. Market mechanisms are a powerful tool to help these parties achieve their targets at lower cost. By giving parties the option to either reduce their own emissions or purchase the emissions reduction credits from others who can do so at lower cost, the market

works to achieve the given emission reduction target in the most cost-effective way.

(1) Clean Development Mechanism (CDM)

Annex I parties can meet their emission reduction targets through flexible market mechanisms such as the Clean Development Mechanism (CDM). The CDM allows an Annex I country to invest in emissions reduction projects in a non-Annex I country to generate Certified Emission Reductions (CERs) that count toward their Kyoto Protocol emission target. In exchange, the non-Annex I country can benefit not just from direct revenue from sale of CERs, but also from increased foreign investments with potential technology transfer.

(2) Emissions Trading

Emissions trading refers to a system for in which parties can buy and sell their carbon credits. It has been established in Europe and North America. For instance, the European Union Emissions Trading Scheme, which commenced in January 2005, involves 12,000 installations from key energy-using sectors, such as power generation, accounting for over 40 percent of the EU GHG emissions.

Emissions trading is thus fast becoming a new industry in its own right. The price of carbon in the EU Emissions Trading Scheme has more than tripled from €7 per ton when trading started in January 2005 to about €22 in January 2006. The global emissions trading market, estimated at €5 billion in 2005, is projected to reach €34 billion by 2012.

(3) Opportunities in Singapore

Singapore is well equipped to facilitate the trading of carbon emissions by the extension of its oil-trading capabilities to this emerging commodity. Singapore is also uniquely positioned, both in terms of geographical location and capabilities, to support its surrounding region to meet their sustainable development and GHG mitigation needs. Asia alone represents about 70 percent of global CDM potential for emissions reduction.

Singapore ratified the Kyoto Protocol in April 2006. As a non-Annex I party to the Kyoto Protocol, Singapore is

The global emissions trading market, estimated at €5 billion in 2005, is projected to reach €34 billion by 2012.

able to host CDM projects. These projects that reduce its GHG emissions, such as those that increase the use of natural gas or improve energy efficiency, would enable even Singapore companies to earn tradable CERs. In fact, local companies, such as IUT Global and SembCorp Environmental Management, have expressed interest in looking at potential carbon credits generated from their solid waste treatment operations in Singapore (capture of GHG).

The National Environment Agency will serve as the Designated National Authority to approve and register CDM projects in Singapore. The NEA will hold meetings and workshops with industries that have an interest in CDM projects.

To foster interest in emissions trading, CDM and related opportunities in Singapore, International Enterprise⁶ Singapore has supported seminars on CDM and emissions trading in Asia.⁷

IE Singapore also launched an iPartners Consortium on Greenhouse Gas Reduction in November 2005. The consortium aims to provide potential carbon-reduction project owners in Asia with sustainable technologies and competencies. The anchor, Asia Carbon, with its one-stop center comprising carbon advisory, carbon finance, and carbon asset management, will work closely with alliance partners such as IUT Global and Hazelberg Asia to develop sustainable development projects, for example in the areas of waste treatment and management solutions, flash recycling, and generation of green power. The consortium is a showcase of the commitment of Singapore-based companies to contribute toward global efforts to mitigate the adverse impact of climate change. This will help develop a new service cluster in emissions reduction in Asia, adding impetus to the development of environmental-friendly services and technologies.

D. Generating Public Awareness

Climate change is a relatively new issue of concern for Singaporeans. General awareness of climate change is low, and even for those who are attuned to the international debate on the subject, the issue can seem far removed from their daily lives, both in terms of its impacts and the actions that can be taken to mitigate climate change.

To raise public awareness on climate change, linking it to the choices and actions of Singaporeans at home, work or play and eventually galvanizing climate change action through simple changes in lifestyles.

It is therefore a clear priority to raise public awareness on climate change, linking it to the choices and actions of Singaporeans at home, work or play and eventually galvanizing climate change action through simple changes in lifestyles.

The long-term nature of climate change is a major psychological hurdle to cross. While Singaporeans do want to ensure a good environment for their future generations, it is also important to show how climate change actions can also benefit Singaporeans more directly, such as through energy cost savings.

The Climate Change Awareness Program was launched by the Ministry of the Environment and Water Resources on Earth Day, April 22, 2006. The Climate Change Awareness Program is spearheaded by the Singapore Environment Council and supported by NEA as well as the Climate Change Organization and Shell, representing a true linkage of the public, private, and people sectors. With a theme entitled “Everyday Superhero,” the Program aims to raise awareness among households and motorists on the basic principals of climate change as well as to show Singaporeans how through simple and painless habits that save energy, save money, and reduce GHG emissions, they can all become “everyday superheroes.” Examples of these habits are given in the Climate Change Awareness Program website at www.everyday-superhero.com.sg.

F. International Participation

Beyond domestic efforts to combat climate change, the global nature of the climate change problem requires participation in global action. As a small island state, Singapore is keenly aware that its environment is a shared entity, and that its economic fate is intertwined with that of the rest of the world.

The UN Framework Convention on Climate Change and the Kyoto Protocol of the UNFCCC are the primary international agreements on climate change. Singapore ratified the UNFCCC in 1997 and acceded to the Kyoto Protocol in 2006, reflecting its commitment to environmental issues.

Singapore continues to participate actively in international climate change conferences and research. Singapore also works closely with many other states at the bilateral level to address climate change challenges of mutual concern. For instance, a 1991 bilateral agreement led to the formation of the Germany-Singapore Environmental Technology Agency, which has organized seminars and conferences on environmental issues, including climate change and renewable energy. As the current chair of the ASEAN Working Group on Environmentally Sustainable Cities and as an urban city-state, Singapore is naturally concerned with energy as it is used in urban environments.

Notes

¹ 1 Singapore dollar (S\$) equals to 0.71 U.S. dollar (US\$); US\$ 1.00 equals S\$ 1.41 (February 21, 2008).

² The United Nations Development Program's Human Development Report 2007/2008, provides a list of countries by Human Development Index compiled on

the basis of 2005 data and published on November 27, 2007. It covers 175 U.N. member countries (out of 192), along with: Hong Kong (SAR of China) and PA-governed territories. 17 U.N. member countries are not included due to lack of data. The average HDI of regions of the World and groups of countries are also included for comparison. The Human Development Index (HDI) is a comparative measure of life expectancy, literacy, education, and standards of living for countries worldwide. It is a standard means of measuring well-being, especially child welfare. It is used to distinguish whether the country is a developed, a developing, or an under-developed country, and also to measure the impact of economic policies on quality of life.

³ UNDP, Human Development Report, 2008.

⁴ The Straits Times, May 31, 2000, as quoted in Yuen B., *Squatters No More: Singapore Social Housing*, Global Urban Development, Volume 3, Issue 1, November 2007.

⁵ For instance, in the United Kingdom, the Department of Environment, Food and Rural Affairs (DEFRA) launched the DEFRA Environmental Reporting Guidelines in June 2005. Up to 140 out of the top 250 UK companies are already reporting on their environmental performance.

⁶ International Enterprise (IE) Singapore is an agency under the Ministry of Trade and Industry spearheading the development of Singapore's external economic wing, www.iesingapore.gov.sg.

⁷ For example, the seminar in November 2005 organized by the UK Presidency of European Union and the Singapore Association of Environmental,

Occupational Health & Safety Companies (SAFEco), addressed different facets of climate change including GHG emissions, renewable energy, CDM, and carbon emissions trading.



THE WORLD BANK

Sustainable Development East Asia and Pacific Region

1818 H STREET, N.W.
Washington, D.C. 20433, USA

Telephone: 202 473 1000
Facsimile: 202 522 1666
Web Site: www.worldbank.org/eapsd and
www.worldbank.org/eapurban

