

energyfor**growth**

National Energy Policy Report

contents

- 02 Foreword
- 04 Executive Summary
- 11 The Changing Energy Landscape
- 21 Our National Energy Policy Framework
- 27 Energy for the Power Sector
- 35 Energy for the Transport Sector
- 41 Energy Efficiency
- 49 Energy and the Environment
- 55 Growing Our Energy Industry
- 63 Achieving Our Energy Goals Through R&D
- 69 Engaging Our International Energy Partners



energy for growth

A bloom. A flower unfolds in vibrancy. Radiating in an infinite myriad of colours and possibilities. It represents the dynamic role that energy plays in sustaining Singapore's economic growth and improving the lives of Singaporeans. This report chronicles our efforts at formulating a holistic, flexible and forward-looking national energy policy framework to secure *Energy for Growth* for Singapore.

FOREWORD



Singapore today offers a high standard of living for all. Our economy is strong and vibrant, and our environment clean and healthy. We have come a long way indeed. From a small British trading outpost, we have built a modern metropolis. In so doing, we have become a model for sustainable growth for many cities around the world.

The energy sector in Singapore is a microcosm of our success. Even without a single drop of oil of our own, we have worked hard to become Asia's leading oil hub. We have also liberalised our electricity market, leading to competitive and affordable electricity prices for Singaporeans.

As a small country, however, Singapore is a price-taker for energy. Far from being just another factor of production, energy is a vital resource for all aspects of modern living. We need energy to light our homes, power our transport systems, and grow our industries. Without a continued supply of reliable and affordable energy, our economy will not be able to function, let alone achieve our vision of becoming a leading, vibrant global city.

In recent years, Singapore, together with the rest of the world, has been facing several challenges to the continued supply and sustainability of energy resources. One key challenge is ensuring our energy security. Having no energy resources of our own, we are dependent on imports of oil and gas for our energy needs, and hence, are vulnerable to the risks of supply disruption. It is imperative that we manage the security of our energy sources. The issues surrounding energy security are multi-faceted, but a key strategy is to diversify our energy sources. To do this, critical infrastructure, well-functioning energy markets and international cooperation are needed. We are pursuing the import of liquefied natural gas, and are supporting the research, development and deployment of new energy technologies.

Another key challenge is the environmental impact of energy consumption. Climate change is one of the biggest environmental challenges facing the world today. Singapore is similarly vulnerable to the effects of global warming. A global solution is needed, but forming a global consensus on the way ahead will not be easy. We are a small country, and our efforts alone will not have any impact on climate change. However, as a responsible global citizen, we will play our part in the global efforts to mitigate climate change.

Moving forward, we need a holistic national energy policy framework to meet our objectives of economic competitiveness, energy security and environmental sustainability. As a small island state with limited indigenous resources, a strong and growing economy is our best defence against high energy prices and climate change. But we need to strike a balance between keeping our economic vibrancy, while ensuring our energy security, and safeguarding our environment.

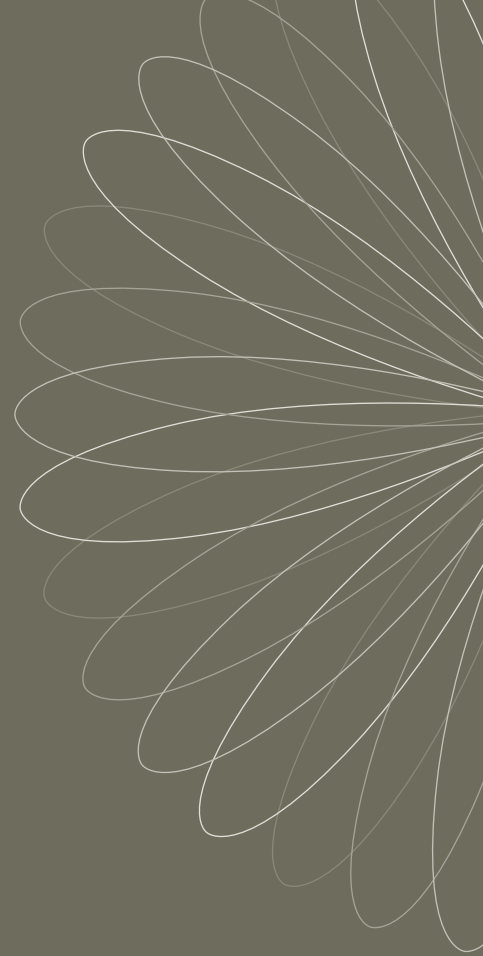
We have been on the path toward sustainable growth for many years. We have succeeded in growing a strong industrial sector, while keeping our environment clean, green and liveable. We have cleaned up all our waterways, managed traffic congestion and have groomed a city in a garden. To further reduce emissions and energy costs, we need a concerted effort from the public, private and people sectors to achieve a stepped-up improvement in energy efficiency and conservation.

We also have a strong base to capture the global opportunities in energy. There are new and exciting opportunities to pursue in clean energy, such as solar power, fuel cells, biofuels, and in energy efficiency. From these, there will be spin-offs in services and other supporting industries that will give an additional buzz and grow Singapore into a global energy hub.

Energy for Growth outlines the challenges and opportunities that the current energy climate presents to Singapore, and Singaporeans. With a robust national energy policy framework and a comprehensive set of energy strategies, all of us can help achieve our vision of making Singapore an even more vibrant and exciting place to live, work and play.



LIM HNG KIANG
MINISTER FOR TRADE AND INDUSTRY
SINGAPORE



EXECUTIVESUMMARY

Energy plays an indispensable role in our economy, and will remain critical to our continued economic growth and development. The ultimate aim of our energy policy is to support Singapore's continued economic growth. As a small country with limited natural and energy resources, we are mindful of the impact that an energy supply disruption could have on our economy and society. The use of energy is also closely linked to environmental concerns over air pollution and greenhouse gas (GHG) emissions. Taking cognisance of the changing global energy landscape, *Energy for Growth* outlines how our energy policies will evolve in tandem so as to address the global energy challenges and to capitalise on the opportunities to sustain our long-term economic growth.

THE CHANGING ENERGY LANDSCAPE

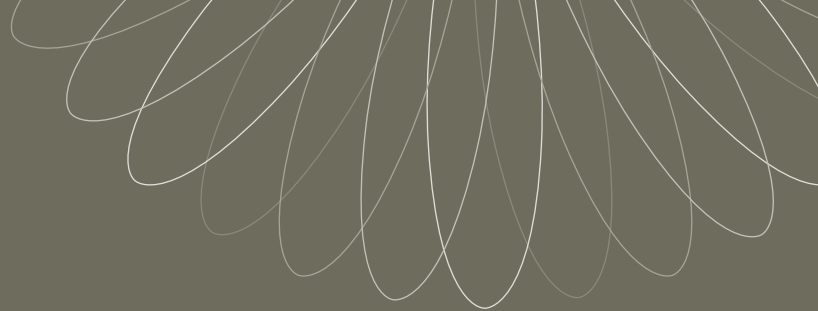
The global energy landscape has changed since the turn of the century. First, the trend of higher oil prices, especially in recent years, is expected to persist over the medium to long term, driven by both demand and supply factors. An expanding world population and strong economic growth, especially 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 our energy needs. We are 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. Our 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, our domestic energy demand is small, and we account for just 0.15 per cent of the world's CO₂ emissions. Much of our energy consumption is used to produce and deliver goods and services to the rest of the world. Our 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 our part in mitigating climate change, through enhancing energy efficiency and developing clean energy technologies and solutions.



OUR NATIONAL ENERGY POLICY FRAMEWORK

Moving forward, the inter-agency Energy Policy Group (EPG) chaired by the Permanent Secretary of the Ministry of Trade and Industry (MTI) 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 our objective of continued economic growth while safeguarding our energy security and natural environment, our focus will be on the following six key strategies:

Strategy 1: Promote Competitive Markets

We are committed to the promotion of competitive markets. This will help keep energy affordable and ensure our economic competitiveness. We have liberalised our electricity and gas markets, and are looking into enabling full contestability in the electricity retail market. Where there are market failures, we will correct them by using market-based instruments or imposing standards and regulations. We will also encourage the private sector to innovate and achieve the energy security and environmental outcomes that we are seeking.

Strategy 2: Diversify Energy Supplies

Energy diversification will help to protect us 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 our limited energy options. Hydro, geothermal and wind power are not available in Singapore, while nuclear energy is not feasible due to our small size. Solar and coal power have some potential, but they face cost and technological barriers, and environmental concerns respectively. Nonetheless, we should not write off any energy option for Singapore. As technology improves, energy sources which 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 three objectives of our energy policy. Using less energy to obtain the same output will decrease our dependence on energy imports and enhance our energy security, while reducing business costs, pollution and CO₂ emissions. The Government has set up an Energy Efficiency Programme 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

We can turn the energy challenges into opportunities by positioning our economy to meet rising global and regional demand for energy. We intend to increase our refining capacity to consolidate our status as Asia's premier oil hub. We will expand the range of energy trading products to include liquefied natural gas (LNG), biofuels and carbon emission credits. We are also pursuing growth opportunities in clean and renewable energy, including solar energy, biofuels and fuel cells. Strong research and development (R&D) capabilities are required to support industry development in these areas, which will also enable us to develop solutions that address our own energy needs.

Strategy 5: Step Up International Cooperation

Given our small size and reliance on energy imports, it is important that our energy policy includes efforts to promote greater regional and international energy cooperation to further our energy interests. To enhance our 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.

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 our energy policy began with the formation of the EPG in March 2006. The EPG 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 six strategies outlined above, the EPG 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 organisational changes have also taken place, such as the creation of a new Energy Division in MTI, the expansion of the Energy Market Authority (EMA), and the creation of the Clean Energy Programme Office (CEPO) and the E²PO. The Government has also set up the Energy Studies Institute (ESI) at the National University of Singapore (NUS) to promote and develop policy-oriented research on the economics, environmental and international relations aspects of energy, as well as contribute to energy dialogue and collaboration within the region.

OUR POWER SECTOR

Competitively-priced and reliable electricity supplies are critical for our economy. The Government has restructured and liberalised 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 our 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 our economy and population grow.

Our fuel mix is much less diversified compared to the global average. About 76 per cent of our electricity is generated from piped natural gas (PNG) transported from Malaysia and Indonesia. To diversify our energy sources, we are planning to import liquefied natural gas (LNG) by 2012. There is value in promoting a more diverse energy system to reduce our 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 our policies are open and flexible enough to enable energy diversification by the private sector. We 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, we should not subsidise energy consumption as this will distort markets and lower incentives for users to conserve energy. Instead, we will promote competitive energy markets to improve efficiency, encourage innovation, and drive down prices. To implement full retail contestability, the EMA is piloting the Electricity Vending System (EVS) which will allow retail consumers to choose their electricity retailers. Incorporating smart metering technologies, the EVS will enable consumers to monitor their electricity consumption and reduce their electricity bill through prudent use of electricity.

OUR TRANSPORT SECTOR

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

For land transport, our 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, we have 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 per cent in the morning peak period by 2020, up from the current 63 per cent. To improve fuel efficiency of vehicles, the Government is considering introducing mandatory fuel economy labelling, 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 Organisation (ICAO) and the International Maritime Organisation (IMO) in addressing the environmental impact of international air and sea transport.

Looking ahead, oil is likely to maintain its dominant role in powering our 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. We will also continue to facilitate R&D on alternative fuels and technologies that can enhance energy diversity, improve energy efficiency and reduce emissions.

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 (NEA). 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 behaviour; 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 programmes to promote energy efficiency include:

a) *Power generation*

Between 2000 and 2006, overall power generation efficiency improved from 38 per cent to 44 per cent due to the switch to oil-fired steam plants to combined cycle gas turbines (CCGTs). The E²PO will also continue to promote cogeneration and trigeneration through, for example, integrating the deployment of these facilities into ongoing and future industrial planning.

b) *Industry*

The Energy Efficiency Improvement Assistance Scheme (EASe) co-funds up to 50 per cent of the cost of energy appraisals for buildings and industrial facilities. Under the Investment Allowance (IA) Scheme, capital expenditure that results in more efficient energy utilisation can be granted a capital allowance that allows a deduction against chargeable income. Programmes will be developed to help companies incorporate efficiency considerations early on in the conceptual design phase of a new facility.

c) *Transport*

To further increase the energy efficiency of our 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 our roads. Policies under consideration include mandating fuel economy labelling, and there will also be efforts to increase public awareness of fuel efficient driving habits.



d) **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 (GFA) above 2,000m² 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.

e) **Households**

We will continue to encourage consumers to purchase energy efficient appliances and to adopt energy saving habits. New initiatives include mandatory energy labelling for all household refrigerators and air-conditioners sold in Singapore, and encouraging households to reduce standby power consumption.

ENERGY AND THE ENVIRONMENT

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

We have formulated a National Climate Change Strategy (NCCS) in 2007 which articulates Singapore's comprehensive responses to climate change. The NCCS 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 (N3C) led by the Ministry of the Environment and Water Resources (MEWR) 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 us to design a robust long-term adaptation response to climate change.

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

We also need to continue to deal with sulphur dioxide (SO₂) emissions from power plants and our oil refining industry. The power generation sector (power plants using oil) and industries account for about 99 per cent of SO₂ emissions and 30 per cent of PM 2.5 emissions. To reduce the levels of these pollutants, we have implemented emission concentration limits for various air pollutants, an overall emission cap for SO₂ and limited the sulphur content of fuels.

OUR ENERGY INDUSTRY

The energy industry is a major contributor to the Singapore economy. Looking ahead, while we envisage that our 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. Our 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.



The following are the developmental strategies to expand our energy industry:

a) *Expand refining base*

Due to strong demand for oil in Asia, there is considerable upside for Singapore to grow our refining capacity from its present 1.3 million barrels per day. We will do this by promoting the expansion and upgrading of our existing refineries and attracting greenfield investments. This will help maintain our share of global refining capacity, and create the liquidity needed to anchor oil trading and price discovery activities in Singapore.

b) *Extend beyond oil trading to energy trading*

We can leverage on our 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, we have introduced a concessionary tax rate of 5 per cent on LNG trading income for companies under the Global Trader Programme (GTP). Emission credits and biofuels are also included as qualifying products under the GTP.

c) *Grow the clean energy sector*

The global market for clean energy technologies is expected to experience tremendous expansion in the next decade. Singapore views clean energy as a key growth area. Our experience and capabilities in the semiconductor, industrial equipment and chemicals sectors put us 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.

d) *Help sustainable energy solutions providers expand regionally*

Rapid urbanisation 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 can capitalise 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.

OUR ENERGY R&D

New energy technologies can help make our energy system more efficient, cleaner and more diversified. Our research institutes, universities, and the 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 (NUS) and the Nanyang Technological University (NTU) 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 centre in Singapore.

Moving forward, we will intensify our energy R&D efforts in areas where we have expertise or competitive advantage. One key new initiative is the Singapore Initiative in New Energy Technologies (SINERGY) Centre which will provide technical infrastructure, such as a microgrid and command and control facility, to facilitate research on clean and sustainable energy solutions. The centre 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 Programme to integrate and expand existing knowledge, as well as work on fuel cells, alternative fuels and next-generation solar technologies. In August 2007, EDB launched the Clean Energy Research and Test-bedding Programme (CERT), which will provide \$17 million in funding to promote the application of clean energy technologies to public sector facilities. The National Research Foundation (NRF) has also set aside \$170 million to boost our clean energy R&D efforts, starting with a focus on solar technologies and fuel cells.

ENGAGING OUR INTERNATIONAL ENERGY PARTNERS

The objectives of our external energy engagement strategy are three-fold:

a) *Promote regional and international energy cooperation to further our energy interests*

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, we participate actively in regional and international fora including ASEAN, EAS and APEC, to promote various initiatives such as energy market integration, energy efficiency and renewable energy. We also support and actively participate 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 our efforts. Although we are a small country, we have been finding innovative ways to contribute meaningfully, such as sharing our 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, we are working with various partners to create the environment to encourage the development of safe and secure nuclear energy for civilian use.

b) *Promote security of vital energy sea lanes in the region*

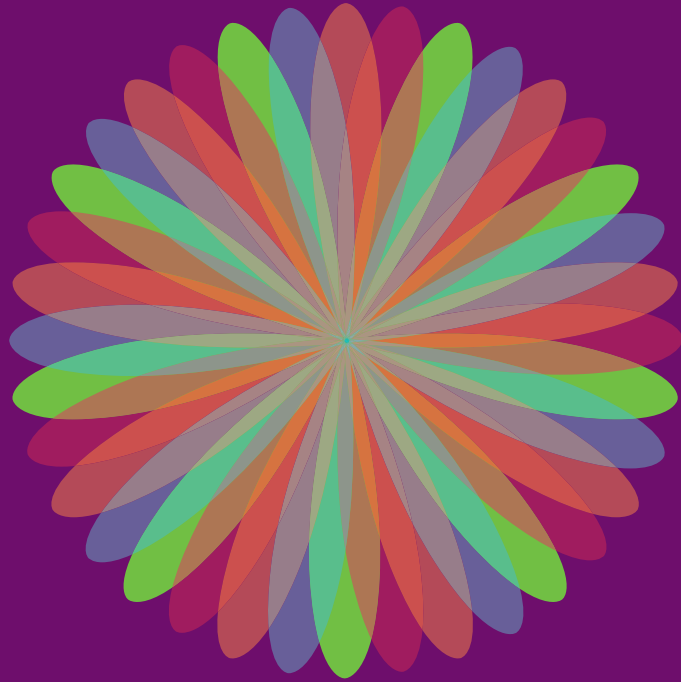
For Singapore and East Asia, the Straits of Malacca and Singapore (SOMS) is an integral part of the critical energy supply route from the Middle East to East and Southeast Asia. The security of transit along the SOMS is critical to the energy security of Singapore and the region. The littoral states of Indonesia, Malaysia and Singapore participate in a range of initiatives to ensure safe transit passage and the freedom of navigation through the SOMS. 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 SOMS.

c) *Promote Singapore as a centre of energy research and excellence*

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

LOOKING AHEAD

Energy for Growth outlines our national energy policy framework and strategies with the aim of achieving economic competitiveness, energy security and environmental sustainability. We must 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, so as to support our continued economic growth.



the changing **energy** landscape

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. We need to address both these challenges and capitalise on the opportunities generated by the changing global energy landscape to sustain our long-term economic growth.

The CHANGING ENERGY LANDSCAPE



In the 1980s to 1990s, when energy prices fell, policymakers in many countries began to treat energy as another commodity that was best left to market forces. The popular energy policy instruments then were the privatisation of state-owned assets, liberalisation of markets and promotion of competition.

The situation has shifted greatly since the turn of this century. First, the quadrupling of oil prices since 2002 has propelled energy security to the top of domestic and international policy agendas. Energy security has, to a large extent, become a part of foreign policy, due to the growing interdependence between countries for energy resources. Second, climate change has emerged as a major environmental concern worldwide. The need to respond to climate change introduces a whole new dimension to energy policy formulation.

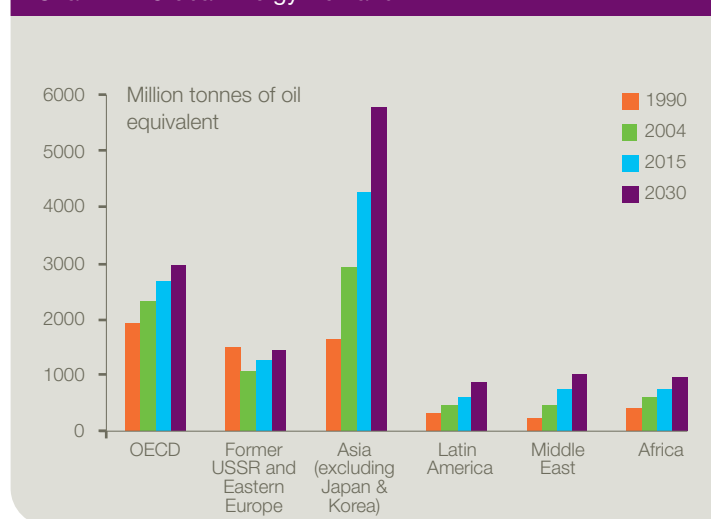
Due to these developments, the scope of energy policy has broadened beyond economic competitiveness to encompass growing concerns over geopolitical uncertainties; disruptive events like natural disasters and terrorist attacks; the impact of climate change; and energy efficiency and conservation efforts. Many countries are also aggressively positioning their economies to capture the economic opportunities that will emerge from the changing global energy landscape.

ENERGY SECURITY

After the last spike in oil prices with the Iranian Revolution at the end of the 1970s, many developed economies went into recession. As a result, global demand for energy fell, and there was excess supply and capacity. The challenge of the 1980s and 1990s was to maximise the use of existing assets and drive down costs through market liberalisation. The focus was on cost reductions rather than investment. Conditions were ripe for a reversal. At the turn of the current decade, the supply-demand gap started to narrow, with demand rising due to low prices, and supply restricted due to under-investment and ageing production facilities.

There is an emerging consensus that the trend of higher oil prices in recent years will persist over the medium to long term, driven by both demand and supply factors. According to the United Nations, world population is projected to rise from 6.7 billion in 2007 to 8.9 billion by 2050. The world economy is expected to continue to grow strongly, powered by high growth rates in China and India. Many developing countries are entering the energy-intensive phase of development as they pursue industrialisation. With incomes rising, consumers in these countries are starting to buy energy-intensive amenities such as air-conditioners and passenger cars. The overall effect is a rapid growth in energy demand. The International Energy Agency (IEA) projects that global energy demand will expand by 53 per cent by 2030 from 2004 levels, based on current policies and trends. In particular, developing Asia will require twice the amount of energy in 2030 compared to today [see Chart 1.1].

Chart 1.1: Global Energy Demand



Source: IEA

On the supply side, capacity is expected to remain tight. There are sufficient energy resources worldwide to allow for capacity expansion to meet rising demand. Thus, the question is whether capacity will expand sufficiently to meet this demand. World proven coal reserves are equivalent to 147 years at 2006 consumption levels, based on the British Petroleum (BP) Statistical Review of World Energy 2007. For oil and gas, proven reserves are estimated to be sufficient for only around 40 and 63 years of 2006 levels of consumption respectively. Nevertheless, oil and gas production is not expected to peak within the next two to three decades. With more exploration and improvements in extraction technologies, substantial new reserves will be added. Since 1980, globally proven oil reserves have expanded by 81 per cent, while proven gas reserves have more than doubled.

However, whether new energy supplies will actually come on-stream hinges on supplier countries making sufficient and timely investments to increase production. This in turn would depend on the investment climate in these countries, as well as their openness to foreign investments. Meanwhile, as conventional oil reserves are being depleted, new reserves have generally been located in more remote and difficult geographies, making them costlier to develop and bring to market. New geopolitical tensions and natural disasters could also disrupt supplies, driving prices higher and increasing price volatility.

Global oil and gas reserves are concentrated in the Middle East, Russia, Central Asia and Africa [see Charts 1.2 and 1.3]. In particular, the Middle East holds 61.5 and 40.5 per cent share of world proven oil and gas reserves respectively. It is inevitable that the world will become increasingly dependent on the Middle East for oil and gas. Geopolitical conflicts in the Middle East will therefore have a greater impact on the world.

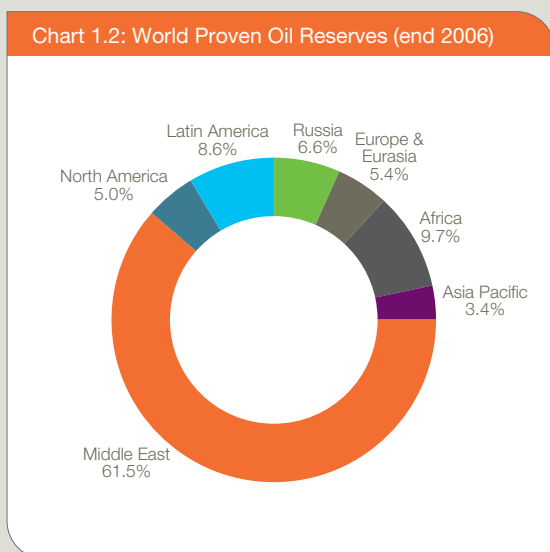
In the oil market, most of the additional supply needed to meet expanding demand will come from member countries of the Organisation of Petroleum Exporting Countries (OPEC), which hold the bulk of the world's oil reserves. OPEC's share of global oil supply will rise, and this will increase its ability to influence oil prices. Nevertheless, OPEC is likely to refrain from driving oil prices up too high, as this might accelerate the development of alternative energy sources and dampen demand for oil.

As with oil, gas reserves are concentrated in a small number of countries. Going forward, natural gas prices are likely to continue to follow the trend in oil prices, due to the prevalent practice of indexing gas prices

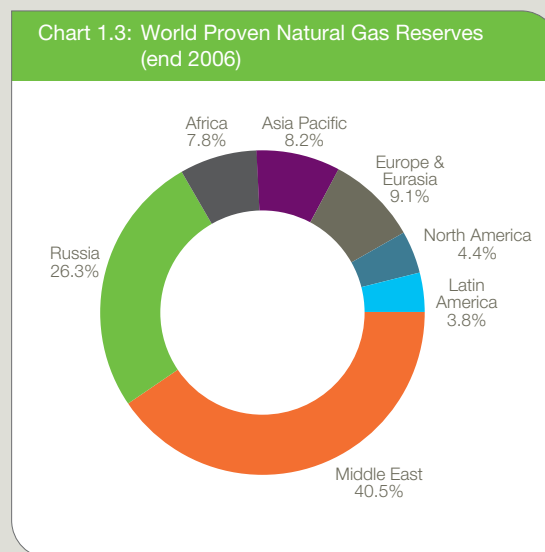
to oil prices. The majority of gas trade is likely to remain governed by long-term contracts. However, as the use of liquefied natural gas (LNG) increases, short-term contracts and spot trading may become more prevalent.

Coal resources are dispersed more widely. Most coal reserves are found in or near the main energy demand centres of North America, Europe and Asia [see Chart 1.4]. Because of this and the cost competitiveness of coal, the use of coal is expected to grow. The IEA has projected coal's share of world energy supply to increase to 26 per cent in 2030 from 24.8 per cent in 2004.

Concerns over energy security, high fossil fuel prices and carbon emissions have also brought about a renewed interest in nuclear energy, including in Asia. Nuclear energy is a proven technology for power generation. Depending on the cost of construction and financing, nuclear power may also be comparable to gas-fired generation in terms of cost-competitiveness. However, nuclear power also brings with it the attendant concerns of nuclear proliferation, safety and nuclear waste disposal.



Source: BP Statistical Review of World Energy



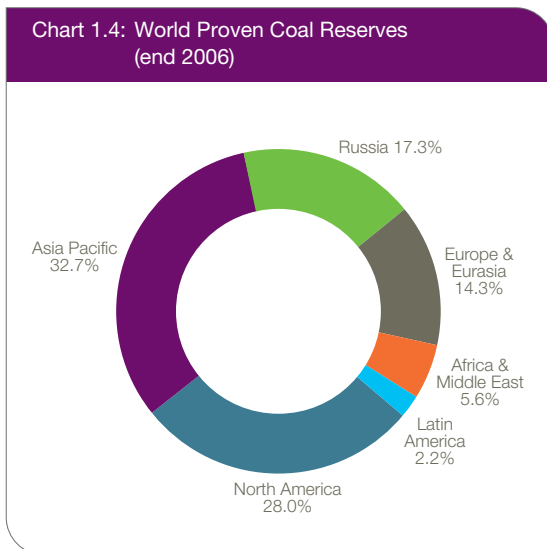
Source: BP Statistical Review of World Energy

ENERGY SECURITY AND SINGAPORE

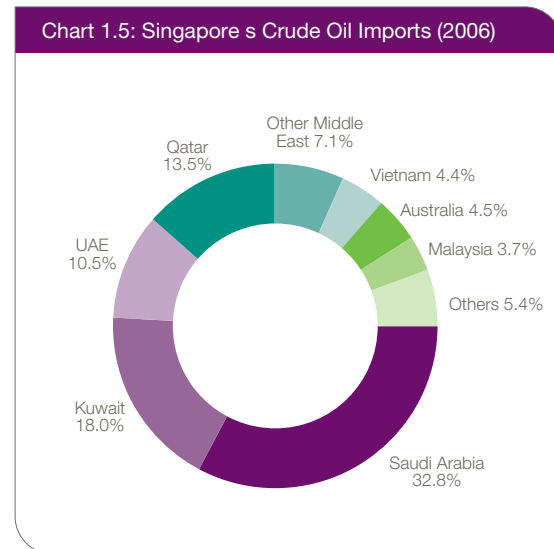
As a small city state without any significant energy resources, Singapore is dependent on imports of oil and natural gas to meet our energy needs. Our reliance on energy imports need not be a problem per se. All countries have a common interest in ensuring the smooth functioning of international energy markets. Supplier countries also have incentives to maintain a stable supply of energy because of their reliance on revenues from their energy exports.

Nevertheless, we remain vulnerable to a number of supply risks, including insufficient investments in production capacity by energy producers, and events such as geopolitical conflicts, social unrest, terrorism, accidents and natural disasters that might cause a temporary disruption in supply. The continued growth of our economy can also be undermined by rising energy prices since our energy costs are fully exposed to global movements in oil and gas prices.

For example, some 80 per cent of our crude oil imports are from the Middle East [see Chart 1.5]. A major crisis in the Middle East will disrupt oil supplies.



Source: BP Statistical Review of World Energy



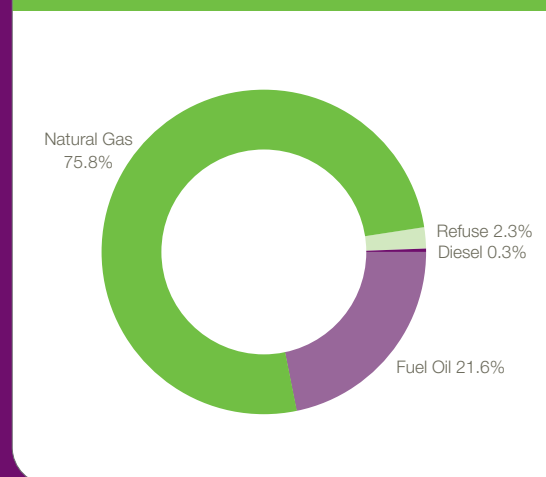
Source: IE Singapore

About 76 per cent of our electricity is generated using piped natural gas (PNG) supplies from Malaysia and Indonesia [see Chart 1.6]. Apart from supply disruptions, we are mindful that our neighbours will increasingly require gas for their own domestic needs. Consequently, less would be available for export to Singapore and other countries in the region.

The liberalisation of our electricity and gas supply markets has brought about efficiency gains and more competitive electricity prices. The transport fuels market is also left to compete freely. We believe that the framework of competitive markets is fundamentally sound and will remain a cornerstone of our energy policy. Competitive markets also incentivise suppliers to achieve energy security, by maintaining their own commercial inventories and diversifying their sources to reduce commercial risks.

However, it has also become clear that the pure market-based approach, in and by itself, will be unable to provide the level of energy security that we need. Energy is so critical that a supply disruption will have tremendous knock-on effects on the economy and society, the full costs of which have not been internalised by the energy industry. In light of the increasing concentration of energy supply in a small number of countries, and the expected tight demand and supply balance in world energy markets going forward, Singapore will require new policy initiatives to reduce our vulnerability to energy supply and price risks.

Chart 1.6: Singapore's Electricity Fuel Mix (1H2007)



Source: EMA



CLIMATE CHANGE

Climate change is one of the biggest environmental challenges the world is facing today. Globally, rising sea levels, warmer temperatures and more extreme weather events have been observed. As noted in the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC)¹, most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in greenhouse gas (GHG) emissions from human activities, primarily carbon dioxide (CO₂) released by the burning of fossil fuels. The global concentration of CO₂ in 2005 was 379 parts per million (ppm), above the natural range over the last 650,000 years of 180 to 300 ppm.

The rate of climate change is predicted to accelerate with rising GHG emissions, with potentially wide-ranging physical, economic and social impact. By 2100, global temperatures are projected by the IPCC to rise by 1.1 to 6.4 °C compared to 1980 to 1990 levels. Global sea levels, which rose by 17 cm in the 20th century, are projected to rise by 18 to 59 cm by 2100.



HSBC Tree top walk at MacRitchie

Climate change can lead to coastal land loss, damage to infrastructure, and displacement of people by rising sea levels and floods; reduced food production; and damage from increased extreme weather events. There could be adverse effects on human health, such as from extended heat waves, spread of infectious diseases, and shortages in water supply. The IPCC reports that economic losses could amount to 1 to 5 per cent of global gross domestic product (GDP) for a 4 °C increase in temperature.

The worst consequences of climate change can be prevented if GHG concentration can be stabilised at a sufficiently low level. However, rather than declining, world energy-related CO₂ emissions are projected to rise by around 50 per cent by 2030, according to the IEA's projections. To reduce emissions or to slow down its growth, the world will need to improve energy efficiency, shift to low carbon energy sources, and remove carbon from the air through carbon sinks, such as reforestation. However, this will not be easy. Energy and carbon are closely tied to our lifestyles and the structure of our economies. It will take several decades to replace current economic capital stock – including cars, industrial machines, power stations, buildings and transport infrastructure – with cleaner, more efficient ones.

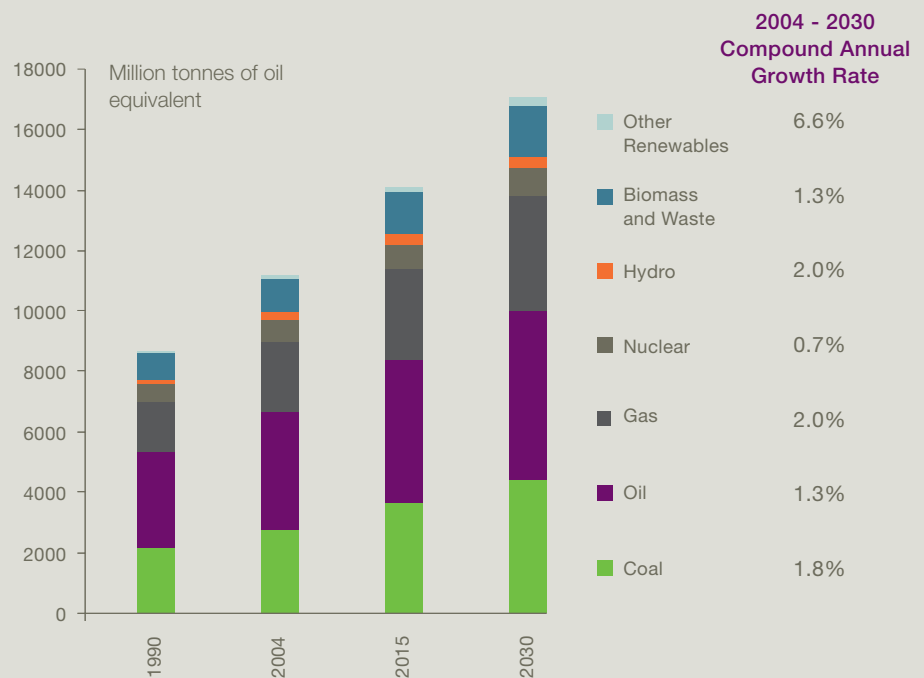
¹ The IPCC was established by the World Meteorological Organisation (WMO) and United Nations Environmental Programme (UNEP) to provide objective information about the causes and potential impacts of climate change. Its reports are authored and reviewed by hundreds of experts around the world.

Concerns over climate change have fuelled a strong growth in demand for renewable energy, supported not just by government subsidies, but also consumers who are increasingly showing a willingness to pay a premium for green energy. The IEA projects that global demand for renewable energy (excluding hydropower and biomass) would grow at about 6.6 per cent a year [see Chart 1.7]. However, the total contribution of non-hydro/biomass renewable energy is expected to be small, at just about 1 to 2 per cent of global energy supply, due to the very low base they are starting from. Fossil fuels will continue to dominate the energy landscape, contributing about 80 per cent of global supply in 2030.

Improving energy efficiency holds great potential to both mitigate CO₂ emissions as well as to promote sustainable national development. Increasing energy efficiency not only reduces GHG emissions, it also improves air quality, reduces energy costs, and helps to improve energy security by mitigating our energy demand growth.



Chart 1.7: Global Primary Energy Supply



Source: IEA

CLIMATE CHANGE AND SINGAPORE

As a relatively low-lying, small island state in the tropics, Singapore will not be spared from the effects of climate change. Our key vulnerabilities to climate change include coastal land loss, increased flooding, impact on our water resources and spread of diseases. There could also be indirect consequences such as a rise in food prices due to agricultural change in other countries, and the opening up of new sea routes through the Arctic that bypass Singapore due to the melting of the Arctic ice caps.

However, Singapore is a small country. Our domestic energy demand is small, and we account for only about 0.15 per cent of the world's CO₂ emissions. If the Singapore economy were to shut down completely for one whole year, the CO₂ savings would be offset by incremental emissions elsewhere in less than two weeks, based on the current rate of global emissions growth. It is clear that our own efforts to mitigate emissions will not have much impact on climate change unless carried out as part of a concerted global effort.

We are also an export-oriented economy, and much of our energy consumption goes into delivering goods and services to the world. For example, our oil refineries have a total refining capacity of 1.3 million barrels per day, although our domestic demand for oil is less than 100,000 barrels each day. Most of our refined oil products are exported to other parts of the world. Given the international mobility of companies, without every country playing a part, action to reduce emissions in any one country may inadvertently lead to a migration of industries to other countries with no reduction in GHG emissions and thus no net environmental benefit to the world.

Climate change is a global problem that requires a global solution. As a responsible citizen of the international community, Singapore will play our part in mitigating climate change. We ratified the United Nations Framework Convention on Climate Change (UNFCCC) in August 1997, and acceded to the Kyoto Protocol in April 2006. We are participating actively in the UNFCCC, and will work to further the aim of getting countries to collectively address the threat of climate change.

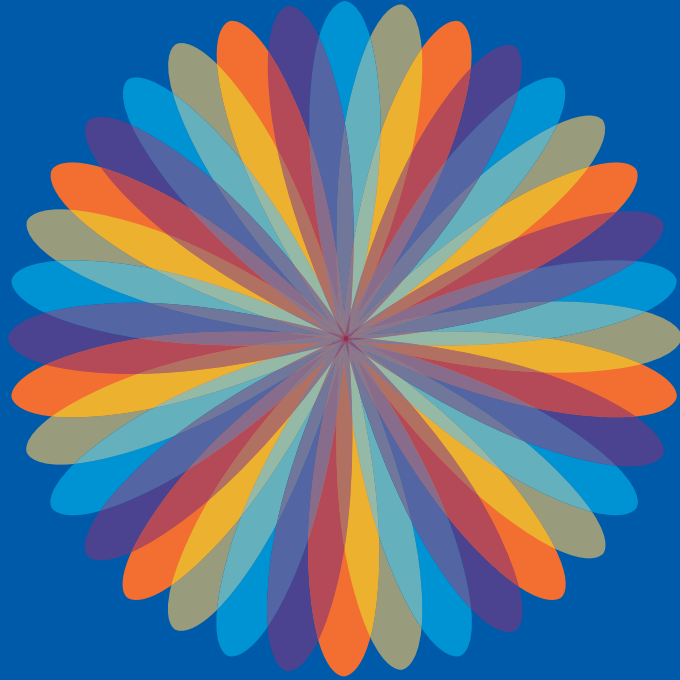
Domestically, we have also been doing our part to address climate change. We have drawn up a National Climate Change Strategy (NCCS) which represents Singapore's comprehensive response to climate change. The NCCS contains actions in the areas of mitigation and adaptation to climate change, and improving Singapore's energy efficiency is a strategic priority in the NCCS.

Besides energy efficiency, the development of clean energy technologies and solutions is another key to overcoming the challenge of climate change. This is another area where Singapore can contribute to the world's search for sustainable energy.

CONCLUSION

Energy plays an indispensable role in our economy. Our energy policy must be designed to ensure that the energy sector will be able to deliver reliable and affordable energy supplies to our population and businesses. In view of the changing energy environment, we need to formulate a holistic framework for energy policy. Such a national framework should be intelligent, flexible and forward-looking in order to address the energy challenges, capitalise on the opportunities generated by the evolving energy landscape, and to sustain our long-term economic growth.





our national **energy** policy framework

Energy policy is complex and multi-faceted. As a city state with limited natural resources, we need to continue to grow our economy as we face the challenges of high energy prices and climate change. We must also strike a balance between the policy objectives of economic competitiveness, energy security and environmental sustainability. Our national energy policy framework will enable us to remain nimble to fine-tune existing policies and formulate new strategies to keep Singapore ahead in the energy arena, and above all, to support our continued economic growth.

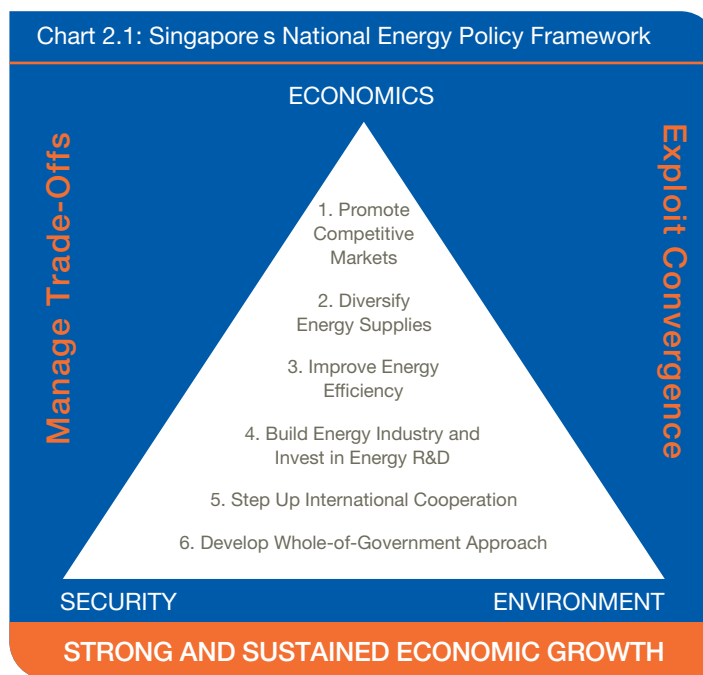
OUR NATIONAL ENERGY POLICY FRAMEWORK



Energy policy is complex and multi-faceted. It does not just cover energy economics, but also energy security and the natural environment. For a small city state, a strong and growing economy is crucial in providing Singapore with the resources needed to meet the challenges of high energy prices and climate change. The core objective of our energy policy must thus be to secure *Energy for Growth*.

At the same time, we need to maintain a balance between the policy objectives of economic competitiveness, energy security and environmental sustainability. For instance, very high energy prices may reduce demand for energy, thus helping to reduce emissions. But these high energy prices may also blunt our competitiveness, leading to a loss of investments and jobs. Besides such trade-offs, there are also areas where the different interests converge. Energy efficiency and conservation, for instance, can often meet all three policy objectives of energy policy. There are also new economic opportunities in areas such as clean energy and carbon trading. Research and development (R&D) of clean energy technologies will not only allow us to capture global economic opportunities, but also develop solutions for domestic adoption that can reduce our carbon signature and lessen our dependence on fossil fuels.

The scale of the energy challenge is immense, and there is no single, simple solution. To meet our objective of continued economic growth while safeguarding energy security and the natural environment, we have developed a national energy policy framework [see Chart 2.1] which encompasses the following six key strategies:



STRATEGY 1: PROMOTE COMPETITIVE MARKETS

We are committed to the promotion of competitive markets. This will help to keep energy affordable, thereby supporting economic competitiveness and raising our growth potential. There is open competition in our oil refining, trading and retailing industries. We have introduced competition into the electricity and gas markets. About 25 per cent of the retail electricity market is still non-contestable, and EMA is looking into the development of an Electricity Vending System (EVS) to enable full retail contestability.

We will also encourage the private sector to innovate and create new opportunities to achieve the energy security and environmental outcomes that we are seeking. The efforts of the private sector to reduce their commercial risks will also contribute to the country's overall energy security. The market can also provide signals for companies to come up with new products and services. For example, a local power retailer has introduced a programme to co-fund the cost of energy audits for its customers.¹

However, we recognise that markets may be unable to deliver broader environmental or energy security policy objectives due to market failures such as externalities. For example, the burning of fossil fuels adds to air pollution, whose social costs are not internalised by the polluter. In this regard, we will need to correct for market failures by using market-based instruments or imposing standards and regulations.

¹ *Tuas Power to help corporate users save energy, The Straits Times, 15 September 2007*

STRATEGY 2: DIVERSIFY ENERGY SUPPLIES

Diversification can help enhance our energy security, by spreading our risks. It is the best way of protecting ourselves against supply disruptions, price increases, and other threats to the reliability of supply. To enhance energy security, we should promote a more diverse energy system. More importantly, we should avoid becoming overly dependent on any energy supplier.

In competitive markets, companies themselves will have incentives to diversify, to reduce their own commercial risks. Technological and market developments can alter the relative competitiveness of different fuels, which will contribute to the diversity of our fuel mix over time. The Government's role is therefore to create an open and flexible framework that allows diversification to take place. The framework must also be stable and predictable, to encourage investment by reducing uncertainties.

However, this approach may not be enough on its own. Specific policies may still be necessary on occasions where markets are unable to provide for sufficient diversity. The Government has to plan ahead with critical infrastructure to permit diversification. For example, the Government has decided to control the import of PNG so as to allow an orderly entry of LNG for our energy needs.

For Singapore, there are also practical challenges to fuel diversification, due to our limited energy options. Hydro, geothermal and wind power are not available in Singapore. Due to our small size and high population density, nuclear power is not feasible. Solar power has some potential given our geographical location, but it faces cost and technological barriers at the moment. Coal power is viable, but the environmental concerns have to be addressed. Nonetheless, we should not write off any energy option for Singapore. As technology improves, energy sources which are not viable for Singapore today may become viable in future. We therefore need to keep a close watch on the development of various energy technologies.

STRATEGY 3: IMPROVE ENERGY EFFICIENCY

Using less energy will help to reduce our dependence on imports and enhance our energy security, while at the same time, cut down our CO₂ intensity, air pollution and business costs. The Government has held to the principle of not subsidising energy, thereby encouraging energy efficiency and conservation. However, market signals are sometimes too weak to promote energy saving practices even though such projects may be cost-effective over the project life cycle. This may be due to a lack of information, split incentives, and higher upfront costs.²

The National Environment Agency (NEA) is working with the relevant agencies through the Energy Efficiency Programme Office (E²PO) to design and implement energy efficiency programmes in each of the sectors of energy use, namely, power generation, industry, transport, buildings and households. It will also undertake public education programmes to cultivate a stronger culture of energy efficiency and conservation.



Artist's impression of TreeTops @ Punggol, HDB's first eco-precinct

² Consumers may not know the energy efficiency rating of the products they are buying, and thus may not fully take into account the cost savings that can be achieved by choosing more efficient products. Split incentives occur when an economic agent does not have an incentive to increase energy efficiency as the cost savings accrue to another party. For example, a developer may not have the incentive to spend the higher upfront costs to build an energy-efficient building, because the tenants are the ones who will enjoy the lower costs of energy.

STRATEGY 4: BUILD ENERGY INDUSTRY AND INVEST IN ENERGY R&D

Developing the energy industry is a critical strategy to turn the energy challenges into opportunities for Singapore. Our approach is to develop the industry centred on providing holistic energy solutions for a city-like environment, by building on our existing strengths and a strong technology foundation. We then apply these solutions to the various energy markets such as transportation, power, industry and buildings.

One key priority is to widen our lead in the oil industry. Specifically, we intend to increase the level of investment and output in petroleum refining. To anchor our position as Asia's premier energy trading hub, we will also increase the range of energy products traded in Singapore, in particular, LNG, biofuels and CO₂ emission credits.

Separately, we will pursue the growth opportunities arising from clean energy, such as solar, fuel cells and biofuels. We will also draw on our strengths in engineering, design and urban planning, to develop sustainable energy solutions and services. To support industry development in these areas, R&D capability is necessary for success. Possessing R&D capability will also enable us to identify, customise or develop solutions that address Singapore's domestic energy needs.

STRATEGY 5: STEP UP INTERNATIONAL COOPERATION

Given the growing interdependence between energy consumers and energy producers, as well as our small size and dependence on energy imports, international cooperation is critical to ensure energy security and effective action on environmental protection. We need to promote greater regional and international energy cooperation, and work with partner countries to enhance the security of key energy transit routes.

Efforts are already underway. For example, we have been playing an

active role in several key fora, including the Association of Southeast Asian Nations (ASEAN), Asia-Pacific Economic Cooperation (APEC) and the East Asia Summit (EAS), to promote greater dialogue and cooperation on energy issues and help develop an open and integrated regional energy market. Under Singapore's Chairmanship, ASEAN Energy Ministers signed the Memorandum of Understanding on the ASEAN Power Grid (APG) in August 2007. Singapore also initiated the establishment of the EAS Energy Cooperation Task Force, and hosted the inaugural EAS Energy Ministers' Meeting. As effective action against climate change can only take place at an international level, Singapore also participates actively in the UNFCCC, as well as discussions on climate change in other fora.

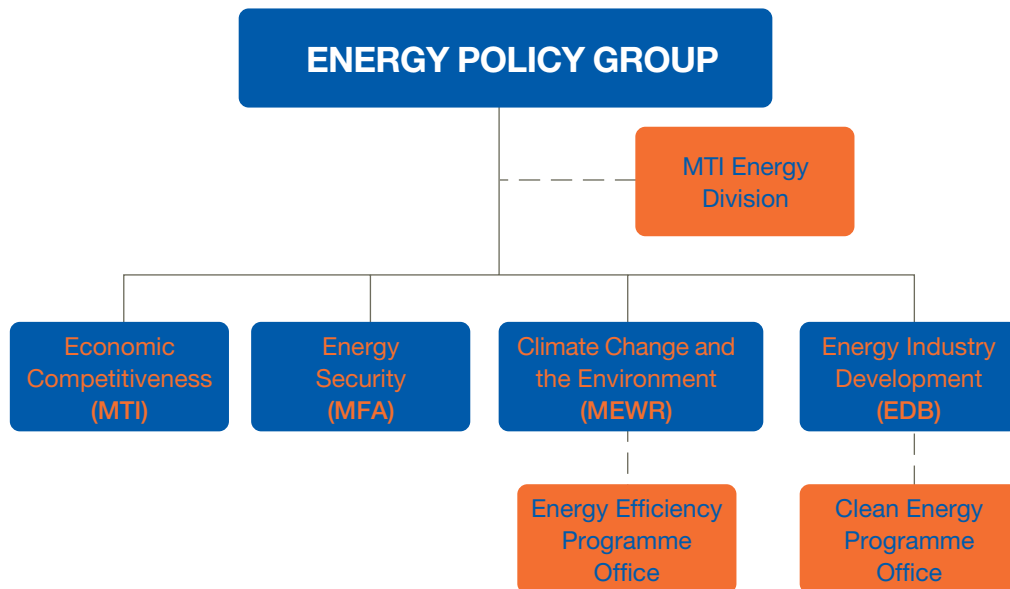
STRATEGY 6: DEVELOP WHOLE-OF-GOVERNMENT APPROACH TO ENERGY POLICY

In the past, the Government's energy policies on energy market regulation, energy industry development, environmental protection and international cooperation, were often pursued individually by the respective ministries or agencies responsible for the issue. However, the growing complexity and strategic importance of energy policy now demands a Whole-of-Government approach.

The work of drawing together the different strands of our energy policy began with the formation of the Energy Policy Group (EPG) in March 2006. Chaired by the Permanent Secretary of the Ministry of Trade and Industry (MTI), EPG consists of senior representatives from the key energy-related ministries and agencies.³ The EPG's efforts are supported by four inter-agency working groups on Economic Competitiveness, Energy Security, Climate Change and the Environment, and Energy Industry Development, each headed by different agencies.

³ The EPG consists of representatives from the Ministry of Finance (MOF); the Ministry of Foreign Affairs (MFA); the Ministry of the Environment and Water Resources (MEWR); the Ministry of Trade and Industry (MTI); the Ministry of Transport (MOT); the Agency for Science, Technology and Research (A*STAR); the Building and Construction Authority (BCA); the Economic Development Board (EDB); the Energy Market Authority (EMA); the Land Transport Authority (LTA); and the National Environment Agency (NEA).

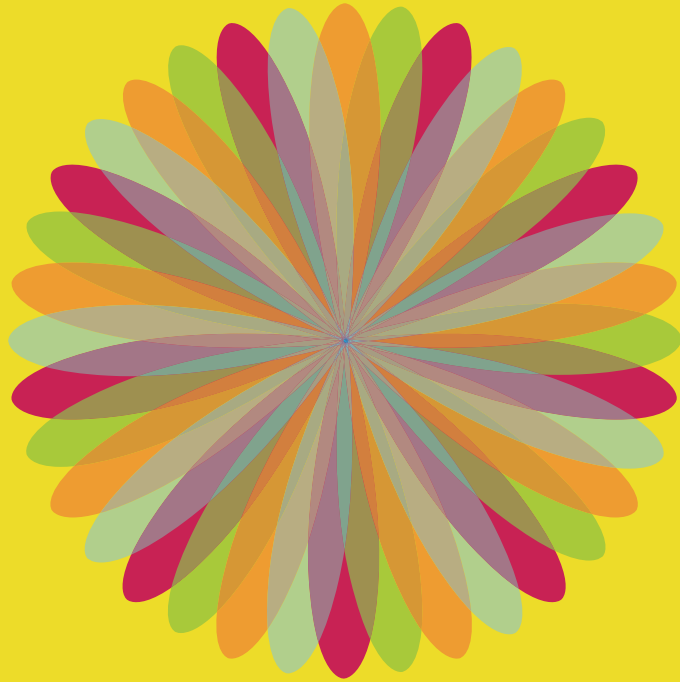
Several organisational changes have also taken place as a result of adopting a national energy policy framework. MTI has formed a new Energy Division, while EMA has also expanded its current focus on electricity and gas markets regulation to take on a bigger role of energy policy and planning on an economy-wide basis. As a statutory board under MEWR, NEA has also been identified as the key agency for climate change and energy efficiency, while the Economic Development Board (EDB) will spearhead the development of the energy industry. EDB and NEA have also established the inter-agency Clean Energy Programme Office (CEPO) and Energy Efficiency Programme Office (E²PO) respectively.



To help us better understand global energy developments and their implications for Singapore, the Government has set up the Energy Studies Institute (ESI) under the auspices of the National University of Singapore (NUS). The ESI will examine the economic, environmental and international relations aspects of energy. Besides being a focal point for energy policy research in Singapore, the ESI will also contribute to energy dialogue and collaboration within the region.

CONCLUSION

The national energy policy framework and its six strategies will help guide us in meeting the global challenges of energy security and climate change. Our energy policy, however, cannot remain static. The global energy landscape is ever-evolving. We need to keep watch and remain nimble, to be ready to fine-tune existing policies and to formulate new strategies when needed, to keep Singapore ahead in the energy arena.



energy for the power sector

Secure and competitively-priced electricity supplies are essential to Singapore's economic competitiveness. To enhance our energy security, we will promote a diversification of energy sources, and support the test-bedding, demonstration, and research and development of new power generation technologies. We will also continue to create and foster greater competition in the power sector to drive costs down through innovation and efficiency gains.

ENERGY FOR THE POWER SECTOR



The availability of reliable and competitively-priced electricity supplies is critical to the continued growth of the Singapore economy. Due to robust economic growth, our electricity demand has grown 2.5 times since 1990. Peak electricity demand has correspondingly risen from 2,500 MW in 1990 to 5,600 MW in 2006.

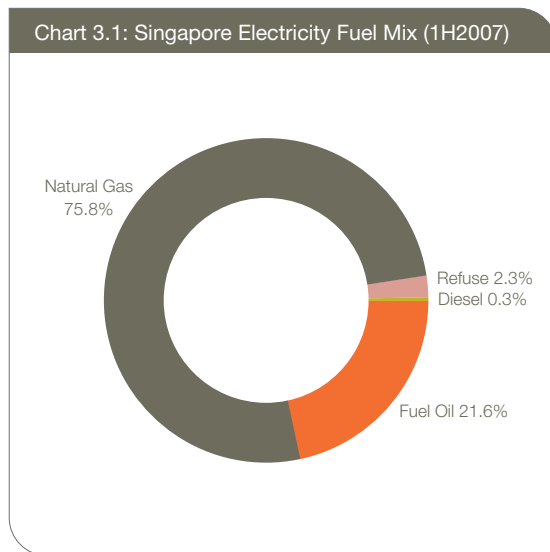
On the supply side, the power sector has undergone several transformations in the last decade. The Government has restructured and liberalised the electricity and gas markets. Market competition has led to the rapid planting of gas-fired combined cycle gas turbines (CCGTs). These developments have brought clear benefits to the economy and the environment. Market competition and fuel switch from oil to gas have improved the competitiveness of electricity prices, reduced air pollution, and lowered our CO₂ intensity.

Our electricity demand is expected to double within the next two decades. The challenge for the power sector is to continue to deliver secure and affordable electricity supplies to all of Singapore, be they households, businesses or industries.

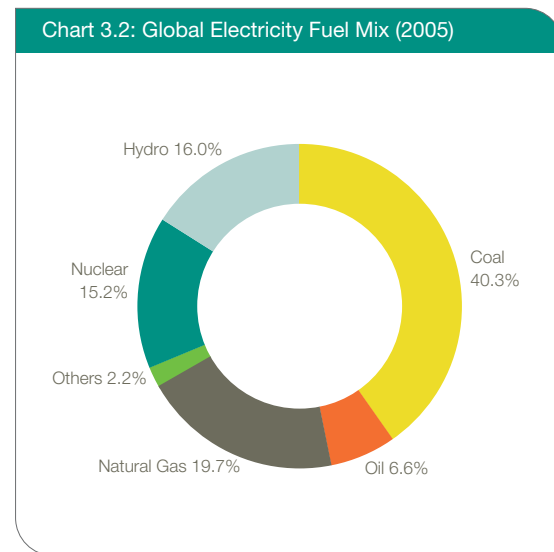
ENHANCING ENERGY SECURITY

Energy security encompasses the management of both supply risks and price risks. Singapore is highly dependent on imported fuels for our power generation needs. This exposes us to a number of supply risks, including capacity bottlenecks in producer countries, and supply disruptions arising from geopolitical conflicts, terrorism and natural disasters. We also face the risk of rising oil and gas prices, which can blunt our economic competitiveness and undermine our growth.

Diversification is the best way to ensure energy security. We should not be overly reliant on a single source for our energy needs. Currently, Singapore has a narrow base of energy sources. In the first half of 2007, 75.8 per cent of Singapore's electricity was generated from natural gas [see Chart 3.1]. Compared to the global average [see Chart 3.2], Singapore's fuel mix is much less diversified. Our natural gas is currently supplied by Malaysia and Indonesia through pipelines. However, due to rapidly rising domestic demand for gas in Malaysia and Indonesia, they may not have sufficient excess gas production to maintain their exports to other countries in the region, including Singapore.



Source: EMA



Source: IEA

To reduce our dependence on piped natural gas (PNG), Singapore is pursuing liquefied natural gas (LNG) importation by 2012 [see Box 3.1]. The LNG terminal is a strategic infrastructure to reduce supply risks, by enabling us to import natural gas from different sources around the world. EMA continues to require our power generation companies to maintain 90 days' worth of fuel reserves stockpiles, to guard against short-term fuel supply disruptions.

Box 3.1: Liquefied natural gas

LNG is natural gas which has been liquefied by cooling it to -160 °C. Liquefaction greatly reduces the volume of natural gas, allowing transportation over large distances by specially-built LNG ships. Upon reaching the destination, LNG can be regasified and injected into the gas network.

On 7 August 2006, the Government announced that Singapore would build a LNG terminal to import LNG to diversify our sources of energy and to meet our future rising demand for energy. The terminal will have a capacity of 3 million tonnes per annum (mtpa) with potential for expansion to 6 mtpa. It will be built on a site of about 30 hectares on the south-western part of Jurong Island. Construction of the terminal is planned to commence in 2009. The terminal is scheduled to take its first delivery of LNG by around 2012. EMA has designated PowerGas Ltd, a wholly owned subsidiary of Singapore Power Ltd, to build and operate the LNG terminal.

Due to the small size of the Singapore market, we will procure LNG through a single buyer or the Aggregator. The successful Aggregator would have an exclusive licence from EMA to import and sell LNG into Singapore up to an initial gas demand of 3 mtpa. The selection of the Aggregator will be done in 2008.

While LNG will open up our sources of gas, it does not reduce our reliance on gas. Our exposure to changes in natural gas prices is greater compared to a country with a more diversified fuel portfolio. We recognise that, in a competitive market, price risks are partly addressed because uncompetitive fuels will exit the market over time and be replaced by cheaper power sources. This has already been borne out in the Singapore electricity market, where we have witnessed the replacement of fuel oil by natural gas. However, entry and exit costs in the power sector are high due to the large, long-term nature of investments. While the market is able to adjust to long-term changes in the economics of fuels, this could still expose the economy to adverse price movements in the short to medium term.

To reduce our vulnerability to supply and price risks, we should promote a more diverse energy system. However, we do not think that it is desirable or practical for the Government to prescribe the fuel mix. Power generation technologies and global energy markets are constantly evolving. Instead of a top-down target for fuel mix which may become irrelevant over time, we believe that the private sector is better placed to make the investment decision on which technologies and fuels to use, so as to meet the electricity needs of consumers. The role of the Government is to ensure that our regulations are open and flexible enough to allow diversification to take place.

While our energy mix in terms of fuel source and type should ultimately be determined by the market, the Government also recognises that specific policies may be needed to facilitate greater energy diversity. For example, we have controlled the import of PNG in order to build up demand for LNG. This move is necessary to ensure that the LNG project is viable in our small market.



Aerial view of Senoko Power Station

New policies are also needed to facilitate the introduction of promising new energy technologies. Our action plan to support the development of emerging energy technologies includes:

a) **Research & Development**

A*STAR has established an Energy Technology R&D Programme, and is setting up the Singapore Initiative on New Energy Technologies (SINERGY) Centre to develop alternative energy technologies and intelligent grid management systems for distributed generation. In addition, the National Research Foundation (NRF) has set aside \$170 million for R&D in clean energy.

b) **Test-bedding and Demonstration**

EMA is setting up a \$5 million Market Development Fund which will help to pay market charges for the test-bedding of new power generation technologies. EDB has also launched a \$17 million Clean Energy Research and Test-bedding Programme to test-bed solar photovoltaic (PV) and other new technologies.

c) **Reducing Cost and Facilitating Grid Connection**

Micro generation capacity of less than 1 MW for self-consumption is already exempted from market charges. In June 2007, EMA removed the registration fee for market participation that was previously imposed on facilities that are selling electricity into the grid. EMA is also reviewing the reduction of the Wholesaler (Generation) Licence fee. In addition, EMA has published a “Handbook for Photovoltaic (PV) Systems” which explains the market and technical issues regarding the connection of PV systems to the grid.¹



¹ The handbook is available at <http://www.ema.gov.sg>

Due to geographical, technological or other practical constraints, Singapore's options to diversify away from oil and gas for power generation are limited [see Box 3.2]. Nonetheless, we should keep all energy options on the table. As technology improves, energy sources which are not feasible for Singapore today may become viable in future.

Box 3.2: Energy options for the power sector

Natural gas (used in CCGTs) is among the most cost-competitive fuels for power generation. It is also the cleanest fossil fuel. Going forward, new power generation plantings in Singapore are likely to be CCGTs. Consequently, the share of natural gas in Singapore's fuel mix is likely to increase.

Fuel oil is an alternative to natural gas for power generation. However, compared to natural gas, electricity generated from fuel oil is about 25 per cent more expensive. As a result, fuel oil's share of the power generation market has fallen sharply over the years. Fuel oil is also less desirable from the environmental viewpoint as its pollutants and greenhouse gas (GHG) emissions are higher compared to natural gas.

Coal is a cost-competitive fuel for power generation that is used in many countries around the world. Although coal itself is dirty, modern technologies are able to reduce emission of pollutants such as particulate matter and sulphur dioxide to acceptable levels. Coal can also be handled and stored cleanly. However, coal plants generate a large amount of ash, which is an issue for Singapore due to our limited space for waste disposal. This can be partly mitigated by using coal with low ash content and recycling a certain proportion of the ash produced (e.g. as cement substitutes). CO₂ emission is another concern as coal plants emit higher levels of CO₂ than oil-fired steam plants. The scope for coal in Singapore will be limited by land availability, because coal plants require more land compared to natural gas plants.

Singapore does not have any **hydro** and **geothermal energy** resources. While there are several possible ways to tap energy from the sea, such as **wave, tidal** or **ocean thermal energy**, many of these technologies are still in the experimental stage. Furthermore, much of our sea space is used for ports, anchorage and shipping lanes, which will limit the application of ocean energy technologies.

Wind energy is a proven technology, but Singapore's wind speeds are too low to generate power efficiently. Annual average wind speed should be at least 4.5 metres per second (m/sec) for a project to be economically viable but the average wind speed in Singapore is only about 2 m/sec. Moreover, larger and more efficient wind turbines require a lot of space, whether on land or at sea. Hence, large scale deployment of wind energy is infeasible in land-scarce Singapore.

Waste incineration, which is classified under biomass, currently contributes a small but significant 2 to 3 per cent of our power output. There are other biomass possibilities, such as biogas from food waste. But biomass' share of our electricity generation may not see any meaningful increase since it is determined primarily by the amount of waste the country produces. Our policies to reduce, reuse and recycle waste will further cap waste production.

Solar PV has greater potential for Singapore because of our relatively high solar radiation. However, solar PV is still about two to three times more expensive than Singapore's low tension tariffs due to the high upfront cost of PV

systems. Nonetheless, the cost of solar PV had historically been falling at about 5 per cent a year, due to improvements in manufacturing processes and technology. Building integrated PV has the potential to improve the economics of PV by reducing building materials cost.

Electricity supply has to be available on demand. One limitation of intermittent renewable energy sources such as wind and solar energy is that they will either have to be fully backed up by other power sources or require investments in energy storage in order to maintain reliability of power supply. When the share of intermittent electricity sources becomes significant, higher levels of spinning reserves are needed to guard against a dip in power output, which will increase system costs.

Nuclear power is an important source of energy in many countries. It is a very low carbon energy source because the fission process does not release CO₂. Depending on the cost of financing, nuclear power can be cost-competitive with coal and natural gas despite its much higher upfront cost. International guidelines recommend that nuclear power stations be sited a distance away from population centres. Given Singapore's limited land area and high population density, nuclear power is therefore not feasible. The need for a long-term solution for nuclear waste disposal is another challenge. No country has yet implemented a long-term solution to the problem of nuclear wastes, although a few countries have plans to build repositories deep underground in areas identified as being geologically stable. International discussion on the use of nuclear energy is still evolving.

ENSURING COST COMPETITIVENESS

An important objective of our energy policy is to ensure that our energy supplies remain affordable to industries, businesses and households. The key strategy to achieve this is by promoting competitive energy markets. Competition improves efficiency, encourages innovation and drives down prices. Competitive markets are the best way to ensure optimal allocation of resources and cost competitiveness.

Until the mid-1990s, the electricity and gas sectors in Singapore were owned and controlled by the Government. Since then, we have restructured and liberalised our energy markets. Today, Singapore has one of the most open energy markets in the world.

In liberalising the energy markets, our approach has been driven by the principles of creating a level playing field and ensuring a high degree of transparency for market players. To create a level playing field, we have separated the contestable segments (e.g. generation, retail) from the non-contestable segments (e.g. transmission and distribution) in the electricity and gas markets. This is to ensure that no vertically integrated monopolies exist to stymie competition.

To minimise regulatory risks, EMA as the regulator ensures that market rules are consistent and subject to a high degree of transparency. It has also set up an independent Rules Change Panel to deliberate on and recommend for approval changes to market rules, to provide assurance that rules would not be changed arbitrarily and without good reason.

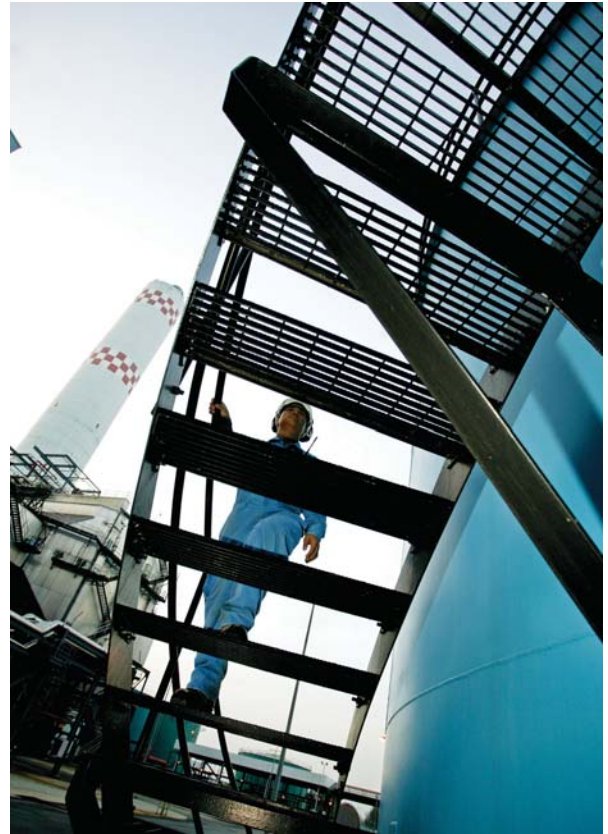
The EMA regulates the non-contestable segments of the market to ensure competitive pricing and allow a reasonable rate of return to investments. Regular benchmarking exercises are done to compare our electricity prices and its various components against charges in other jurisdictions.

As of now, around 25 per cent of the electricity retail market is still non-contestable. This comprises 1.1 million domestic and small non-domestic consumers who have an average monthly consumption of less than 10,000 kWh, i.e. a bill size of less than \$2,000 per month.² These consumers buy electricity from SP Services Ltd at regulated tariffs.

The EMA is studying the feasibility of introducing retail contestability for small users. An idea that is already undergoing pilot testing is the Electricity Vending System (EVS). The EVS is an innovative concept that integrates smart metering technology with e-payment systems to enable consumers to buy electricity from any electricity retailer at various points-of-sale. With the smart metering technology, electricity consumption of consumers can be read by the half-hour. This will allow users to shift consumption from periods of high electricity prices to periods of lower prices, helping to shave peak demand and reduce overall power system costs. EMA is in the process of developing a prototype EVS. If found feasible, the EVS would provide a platform through which retail contestability for small consumers can be introduced.

While we want to keep energy supplies affordable, we will uphold the principle of not subsidising energy consumption. Faced with artificially low energy prices, consumers will have less motivation to conserve energy. Furthermore, subsidies, if applied unevenly or only to certain energy technologies, will distort the level playing field in the electricity market, resulting in a sub-optimal allocation of resources.

² Assuming electricity price of \$0.20/kWh



CONCLUSION

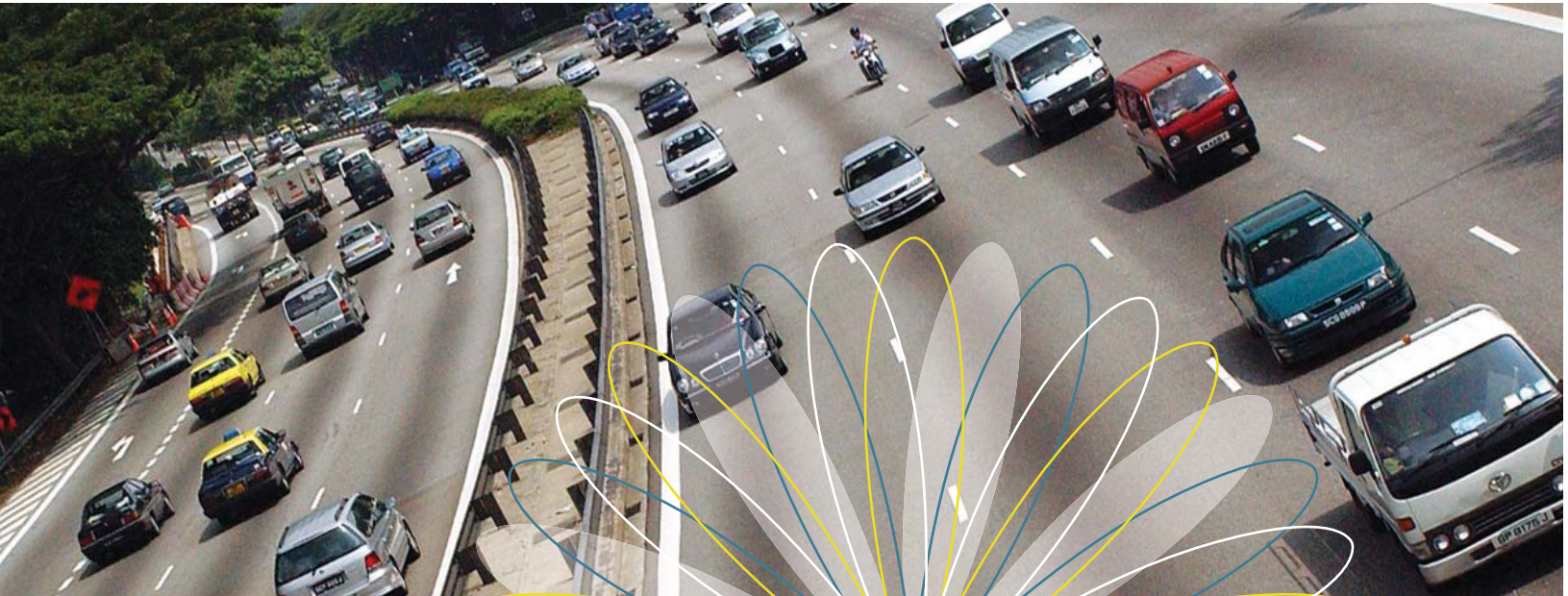
Secure and competitively-priced electricity supplies are essential to Singapore's economic competitiveness. To enhance energy security, we will promote a diversification of energy sources, and support test-bedding, demonstration and R&D of new power generation technologies. We will also continue to create and foster greater competition in the power sector to drive costs down through innovation and efficiency gains.



energy for the transport sector

In providing a world-class infrastructure for transport, we are cognisant of the need to enhance our economic competitiveness, maintain a high standard of living for Singaporeans, and protect the environment. We strive to develop a transport sector that is competitively-priced, flexible, fuel efficient, and provides a diversity of energy options that would safeguard public health and the environment.

ENERGY FOR THE TRANSPORT SECTOR



An efficient and cost-effective transport sector is crucial for enhancing our economic competitiveness and our quality of life. We have a high quality and efficient land transport system that enables us to move people and goods across the island with ease. Singapore is also a major international aviation and maritime centre.

Besides supporting other sectors of the economy, the transport sector itself is a major economic pillar, contributing 9.6 per cent of Singapore's gross domestic product (GDP) in 2006. The management of our transport system forms part of the broader approach to support economic competitiveness, promote environmental sustainability and provide a high standard of living for Singaporeans.

LAND TRANSPORT

Our land transport policy aims to develop a high quality, integrated, efficient and affordable land transport system that will meet the needs of Singaporeans and support our economic and environmental objectives. Our strategies of promoting the use of public transport and innovative policies to restrain car ownership and usage (such as through the Vehicle Quota System (VQS)¹ and Electronic Road Pricing (ERP)²) will help to address the energy challenges by encouraging fuel efficiency and conservation during travel. To mitigate the impact of the consumption of transport fuels on public health and the environment, we have also put in place policies such as mandatory vehicle inspections, vehicular emission standards, and promotion of fuel efficient and green vehicles.

Emission from Vehicles

Similar to other cities, emission from the combustion of fuels in vehicles in Singapore are a significant source of urban air pollution. Vehicular emissions contribute to ambient concentrations of air pollutants such as sulphur dioxide (SO₂), oxides of nitrogen (NO_x), carbon monoxide (CO) and particulate matter (PM).

Vehicles also emit CO₂ from the combustion of fossil fuels such as petrol, diesel and natural gas. The land transport segment accounted for 19 per cent of Singapore's CO₂ emissions in 2005.

Of concern in Singapore is PM 2.5, which is particulate matter finer than 2.5 microns. PM 2.5 is associated with health conditions such as acute bronchitis, aggravated asthma and respiratory diseases. Like many other major cities in the world, Singapore (23 µg/m³ in 2006) has

not met the standard of 15 µg/m³ for PM 2.5 recommended by the US Environment Protection Agency (USEPA), although we are able to meet the USEPA yardsticks for other pollutants including SO₂, CO, nitrogen dioxide (NO₂) and ozone.

Diesel vehicles (including commercial vehicles, buses and taxis) account for about 50 per cent of the PM 2.5 in Singapore's ambient air. Despite advances in diesel engine technology which have helped to improve emissions from diesel vehicles considerably, studies have shown that diesel vehicles currently still emit significantly higher levels of PM 2.5 than petrol vehicles.

A greater push toward promoting public transport, improving fuel efficiency and reducing emissions in land transport would contribute significantly towards cleaner air and better quality of life for Singaporeans.

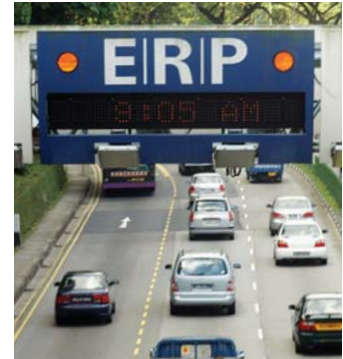
Major Land Transport Thrusts

To meet both our environmental and transport objectives, the Government has embarked on a comprehensive review of our land transport policies and targets. As public transport is the most efficient and sustainable form of motorised transport, we are targeting to achieve a public transport modal split of 70 per cent in the morning peak period by 2020, up from the current 63 per cent.

Our major thrusts going forward for the land transport segment include promoting public transport and non-motorised modes of transport, improving vehicular fuel efficiency, and promoting the use of cleaner fuels.

¹ VQS was introduced in 1990 with the objective of pegging long-term vehicle population growth at a sustainable rate. Under the VQS, potential buyers need to bid for a Certificate of Entitlement (COE) before they can register their vehicles.

² ERP, introduced in 1998, manages congestion so that traffic can flow smoothly on the roads. Motorists are charged when they drive past an ERP gantry during operational hours. ERP charges vary according to the level of congestion, hence different amounts are charged at different locations and times.



Promoting Public Transport and Non-Motorised Forms of Transport

The merits of promoting public transport can be seen from a comparison of the relative energy use by various modes of transport. It is estimated that a car carrying only the driver uses nine times the energy used by a bus and twelve times that used by a train per passenger-kilometre transported.

The Government will continue to promote public transport as it is the most efficient form of transport in land-scarce Singapore. We aim to make public transport a choice mode to attract even the car owners to consider using it for their daily commute. For example, we will encourage and facilitate improvements in the provision of service information and priority schemes for public buses, and work with the public transport operators to raise service levels.

Due to the high mileage of taxis, diesel taxis contribute a significant amount to our CO₂ and PM 2.5 emissions. To address this, we are exploring ways to reduce the empty cruising of taxis and increase the proportion of green taxis (e.g. compressed natural gas (CNG) taxis) in the total taxi fleet.

We should also not discount the contribution of non-motorised transport like cycling and walking towards a sustainable transport system. These include providing better walkways, cycling facilities, and sheltered links between transport nodes and nearby buildings.

Improving Vehicular Energy Efficiency

The voluntary fuel economy labelling programme for vehicles has been in place since June 2003. This programme is aimed at helping car buyers make more informed choices when shopping for a car, taking into account the energy consumption and running cost of different car models. However, less than 20 per cent of the car models in Singapore have been labelled with fuel economy information as of August 2007. The Government is therefore considering mandating fuel economy labelling.

Fuel efficient driving habits such as maintaining the appropriate tyre pressure and reducing idling can yield 5 to 10 per cent reduction in fuel consumption. Other driving habits such as gradual acceleration and avoiding abrupt braking can also result in safer driving, better comfort, less pollution and less noise. Information on the cost savings and environmental benefits of such driving habits will be part of an overall climate change public awareness programme.

Encourage use of cleaner fuels and vehicles

Promoting cleaner fuels (such as CNG) and vehicles (such as petrol-electric hybrid cars) will help to reduce both CO₂ and PM emissions. Our strategies and initiatives to encourage the use of cleaner fuels and vehicles are described in Box 4.1.

Box 4.1: Encouraging the use of cleaner vehicles and fuels

Cars

Since 2001, the Government has been offering the Green Vehicle Rebate (GVR) to encourage the take-up of green vehicles like petrol-electric hybrid and CNG cars. In January 2006, the Government increased the GVR from 20 per cent of the open market value (OMV) to 40 per cent of OMV to offset the Additional Registration Fee (ARF). The rebate serves to make the life-cycle cost of a mid-range petrol-electric hybrid car more comparable to that of a conventional petrol model, to encourage car buyers to choose hybrid cars.

To bring down the PM 2.5 levels in Singapore, the NEA has introduced ultra low sulphur diesel in December 2005 and implemented the Euro IV emission standard for new diesel vehicles registered from 1 October 2006. Other measures and initiatives to reduce emissions include roadside enforcement and a mandatory vehicle inspection regime. NEA will continue to monitor the air quality and tighten the vehicle emission standards as necessary.

Euro IV diesel passenger cars still emit higher levels of PM 2.5 than petrol cars. But in recognition of the cleaner Euro IV diesel engines, the special tax applicable to Euro IV-compliant diesel passenger cars has been reduced to four times their current road tax. The special tax for non-Euro IV compliant diesel passenger cars however remains at six times their current road tax. The Government will continue to review and harmonise the tax structure for diesel passenger cars over time when more stringent emission standards are implemented.

Buses, Taxis and Commercial Vehicles

Most buses, taxis and commercial vehicles today run on diesel. As a group, these diesel-run vehicles emit a large amount of PM due to their large numbers. Hence, the improvement to the environment, in terms of PM, is very significant if these diesel vehicles convert from Euro II to Euro IV. Since October 2006, the Government has made it mandatory for new diesel vehicles to be Euro IV compliant. Currently, the GVR is also applicable to green buses, taxis and commercial vehicles.³ We will continue to study if the GVR can be enhanced to encourage more bus, taxi or commercial vehicle operators to switch to cleaner fuels or vehicles.



³ The GVR is 5 per cent of OMV for green buses and commercial vehicles, and 40 per cent for green taxis.

AIR AND SEA TRANSPORT

Singapore is a major international aviation and maritime hub. For air and sea transport, the Government is aware of the impact of emissions on the environment and we are supportive of global efforts to reduce this impact.

Being a major aviation hub, Singapore is committed to work with the international aviation community to address any environmental concerns. Specifically, Singapore actively contributes to the work of the International Civil Aviation Organisation (ICAO) in mitigating the possible effects that international flights may have on the environment.

For sea transport, Singapore is participating in international discussion on minimising energy usage and pollutive emissions from ships. Being a major hub port and ship registry, Singapore supports clean and efficient shipping. Singapore is currently an active member of a study group, commissioned by the International Maritime Organisation (IMO), which looks into reducing emissions of air pollutants from ships.

MEETING THE DEMAND FOR FUELS

In line with global trends, our transport energy needs are primarily met by oil, with the exception of electricity for the Mass Rapid Transit (MRT) and Light Rail Transit (LRT) systems.

As Singapore does not have any indigenous oil resources, we are dependent on imports of crude oil and refined oil products to meet the energy needs of our transport sector. Our dependence on imports need not be a problem per se as all countries have a common interest in the proper functioning of the oil market. The global oil market had continued to function even during the 1970s oil crises, the 1991 Gulf War and the 2003 Iraq War.

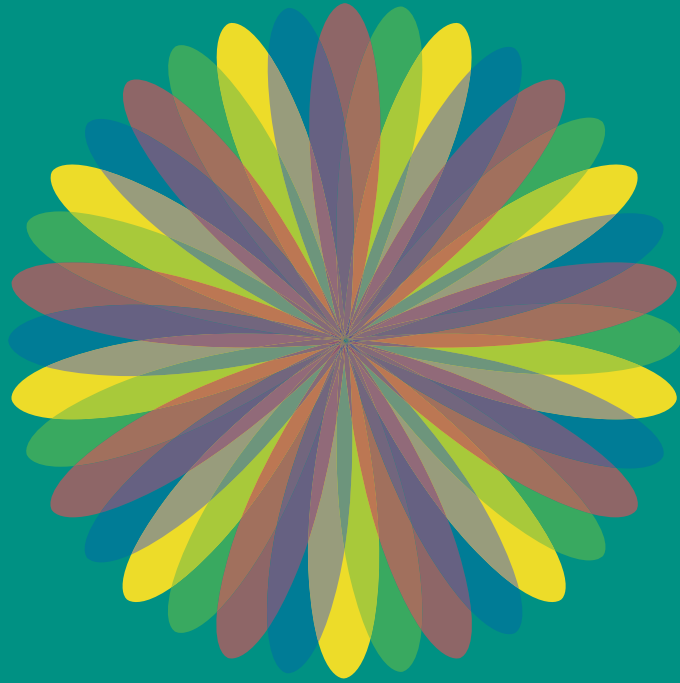
The security of our transport fuels supply is boosted by our large oil industry. Our refineries have more than sufficient capacity to meet our demand for land and aviation fuels. As the world's top marine bunkering port, we import large amounts of fuel oil to supply to ships that call on our ports for refuelling. The Government does not mandate stockpiling for transport fuels. However, there are sufficient commercial oil inventories to supply Singapore's domestic transport needs for many months.

Looking ahead, oil is likely to maintain its dominant role in powering our vehicles, aircrafts and ships, but there could also be opportunities for the entry of alternative fuels as technology improves and these fuels become cost competitive.

For the land transport segment in Singapore, there are on-going private sector efforts to use CNG for vehicles and to test-bed alternative fuels such as biodiesel. Where necessary, the Government will look into the setting of relevant standards to assist adoption. We will also continue to facilitate R&D on alternative fuels and technologies that can enhance energy diversity, improve vehicle energy efficiency and reduce emissions. The Land Transport Authority (LTA) and EDB jointly manage a Technology Innovation and Development Scheme (TIDES), which allows companies to register vehicles used for R&D and testing of new transport technologies with the waiver of vehicle taxes.

CONCLUSION

In providing a world-class infrastructure for transport, we are cognisant of the need to enhance our economic competitiveness, maintain a high standard of living for Singapore, and protect the environment. We seek to ensure that our policies will help to develop a transport sector that is competitively-priced, flexible, energy efficient, and provides a diversity of energy options that will safeguard public health and the environment.



energy efficiency

Using energy more efficiently will help to decrease our dependence on energy imports and enhance our energy security, while reducing business costs and emissions. Energy efficiency is one of the most practical ways in which, through simple lifestyle and habit changes, every Singaporean can contribute towards saving energy and safeguarding the environment.

ENERGY EFFICIENCY



Energy efficiency is an integral part of Singapore's energy policy. While energy demand is expected to grow in the future due to economic growth and an increasing population, part of this growing energy demand can be met by using energy more efficiently instead of increasing energy production.

Increasing energy efficiency in Singapore serves to reduce GHG emissions and reduce air pollutants such as sulphur dioxide (SO₂) and particulate matter (PM). The adoption of more efficient technologies or practices will result in cleaner air and better quality of life for Singaporeans while allowing Singapore to contribute towards mitigating climate change.

In addition, higher energy efficiency will result in overall cost savings to businesses and consumers, particularly when the life-cycle costs of energy efficient investments are taken into account. This helps to cushion the impact of rising energy costs. A more energy efficient economy would ensure that Singapore remains competitive in the long term. We can also export energy efficient technologies and design capabilities.

As Singapore is almost entirely dependent on imported fossil fuels for its energy needs, the prudent use of energy through energy efficiency measures would also help to reduce this dependency.

ENERGY EFFICIENCY PROGRAMME OFFICE (E²PO)

Although energy efficiency makes financial sense, energy efficiency measures may not be implemented due to market barriers such as lack of information. To drive energy efficiency improvement in Singapore and overcome these market barriers, the NEA has established the Energy Efficiency Programme Office (E²PO), an inter-agency committee led by NEA and comprising EMA, EDB, LTA and BCA. It has identified the following action areas to develop a holistic energy efficiency plan for Singapore, known as Energy Efficient Singapore (E² Singapore):


- a) Promote the adoption of energy efficient technology and measures by addressing the market barriers to energy efficiency;
- b) Build capacity to drive and sustain energy efficiency efforts, and develop the local knowledge base and expertise in energy management;
- c) Raise awareness and reach out to the public and businesses to encourage energy efficient behaviour and practices; and
- d) Promote R&D to enhance Singapore's capability in energy efficient technologies.

A SECTORAL APPROACH TO ENERGY EFFICIENCY

In developing its plans and programmes, the E²PO will primarily target five sectors, namely power generation, industry, transport, buildings and households. The E²PO will also develop policies and measures to encourage the adoption of cost-effective energy efficient measures.

As described in Chart 5.1, in terms of fuel consumption, the power generation (51 per cent), industry (32 per cent) and transport (16 per cent) sectors are the largest consumers of fuels in Singapore. The electricity generated by the power generation sector is mainly consumed by industry (22 per cent), buildings (16 per cent) and households (9 per cent).

Chart 5.1: Energy Consumption by Sectors in 2005

	Power Generation	Industry	Transport	Buildings	Households	Others*
Fuel Consumption	51%	32%	16%	<1%	<1%	-
Electricity Consumption		22%	2%	16%	9%	2%
End-Use Consumption		~54%	~18%	~17%	~10%	~2%

*Includes consumption for utilities, communication, construction, agriculture, etc.

The following outlines the ongoing and planned programmes to promote energy efficiency in the five main sectors of energy use in Singapore:

(i) Power Generation

Efficiency in power generation in Singapore has come a long way over the last decade. With the implementation of a competitive electricity market that incentivises efficient power generation, we have seen a switch from oil-fired plants to more efficient, clean and low carbon gas-fired combined cycle gas turbines (CCGTs). Between 2000 and 2006, overall power generation efficiency improved from 38 to 44 per cent.

Other technologies that can improve fuel utilisation and reduce GHG emissions are cogeneration and trigeneration. Cogeneration refers to the integrated production of heat and electricity, while trigeneration refers to the integrated production of electricity, heat and chilled water. These technologies optimise the heat utilisation from fuel combustion and improve overall system efficiency. Examples of the application of such technologies include SembCogen's 815 MW combined cycle cogeneration plant, ExxonMobil's 155 MW cogeneration facility, and Pfizer's 5 MW trigeneration plant. In view of the energy efficiency potential offered by these technologies, the E²PO will continue to promote cogeneration and trigeneration in Singapore.

For cogeneration and trigeneration to be viable, a combined demand for electricity and heating (as well as cooling in the case of trigeneration) must be present. Hence, cogeneration and trigeneration facilities would have to be sited in close proximity to industries in need of the utilities. E²PO will integrate the deployment of cogeneration and trigeneration facilities into ongoing and future industrial planning.

(ii) Industry

Energy efficiency in industry can result in higher productivity and better profitability. The most energy intensive industries in Singapore are the oil refining, petrochemicals, electronics and pharmaceuticals industries, which are important to our economy. Some measures that we are pursuing to encourage energy efficiency in the industry sector include:

a) EASe Scheme

To encourage and help companies identify potential improvements in energy efficiency, NEA introduced the \$10 million Energy Efficiency Improvement Assistance Scheme (EASe) in 2005. Under EASe, NEA co-funds up to 50 per cent of the cost of energy appraisals for buildings and industrial facilities. Each dollar spent on an energy audit uncovers about \$5 to \$10 of annual savings in energy costs with the energy efficiency investments having an average payback period of less than 3 years. As of September 2007, 70 applications for the EASe scheme have been approved, with total anticipated cost savings of more than \$16 million.

b) Investment Allowance Scheme

To encourage companies to invest in energy efficient equipment, EDB administers the Investment Allowance (IA) Scheme which is a capital allowance on qualifying equipment costs that allows a deduction against chargeable income. The IA can be awarded if the capital expenditure results in more efficient energy utilisation.

c) Energy Efficiency by Design

It is often most cost-effective to incorporate energy efficiency measures at the design stage of a facility. We will develop programmes to help companies incorporate efficiency considerations during the conceptual design phase of a new facility.

(iii) Transport

Vehicles are significant emitters of greenhouse gases and air pollutants in many countries. Singapore is no exception. As a result of policies that have promoted public transportation over the years, Singapore has a relatively low private vehicle ownership compared to other developed countries.

We strive to further increase the energy efficiency, and consequently, reduce the environmental impact of land transport. To do so, our land transport policies will focus on encouraging greater use of public transport and more fuel efficient vehicles, as well as reducing congestion on our roads.

(iv) Buildings

Energy efficiency is one of the main considerations in the assessment of a building's environmental credentials. Since the introduction of the Ministry of National Development (MND) Research Fund for the Built Environment in December 2006, agencies such as BCA and NEA have encouraged the development and construction of energy efficient buildings. Energy efficient buildings enjoy substantial cost savings compared to the average building because energy costs are often the largest component of a building's total operating cost.¹ Some of the energy efficiency initiatives that we are working on in this sector include:

a) EASe for Buildings

The EASe scheme is also available to building owners and operators. Energy appraisals can be utilised to identify potential improvements in energy efficiency and to plan appropriate measures to improve energy performance.

b) EnergySmart Label

In 2005, NEA and the Energy Sustainability Unit (ESU) of the National University of Singapore (NUS) launched the EnergySmart Labelling Scheme for offices to recognise energy efficient office buildings in Singapore. Buildings that achieve energy performance equal to or better than the top 25 per cent in terms of energy efficiency and meet good indoor air quality standards are eligible for the EnergySmart Building Label. This scheme was extended to include hotels in 2007.²

c) Building Control Regulations

In Singapore's tropical climate, it is not surprising that air-conditioning forms a major part of our electricity demand. BCA has established the Envelope Thermal Transfer Value (ETTV) standard to reduce heat transfer from the external environment into air-conditioned spaces so as to reduce the air-conditioning load of buildings. Other building control regulations include minimum efficiency requirements for commercial air-conditioners and a maximum lighting power budget.



Artist's impression of City Square Mall, the first private sector development to win the Green Mark Platinum Award

¹ For example, after carrying out an energy audit and retrofit on its air-conditioning plant at its Paya Lebar headquarters, SingPost will save \$1.2 million a year.

² The Regent Singapore, one of the four in the first batch of Energy Smart Hotel buildings, has been able to reduce the energy consumption of its chiller plant significantly, and is enjoying savings of \$77,000 annually.

d) **Green Mark Buildings**

The Green Mark scheme is a green building rating system launched by BCA in 2005 to evaluate a building based on its environmental impact and performance. It encourages the incorporation of environmentally friendly and energy-saving features in buildings. Buildings are awarded Platinum, Gold^{PLUS}, Gold, Certified or ratings depending on the points scored on several key criteria [see Box 5.1]. From 2008, all new and existing buildings with gross floor area (GFA) above 2,000m² that are undergoing major retrofitting works must meet the Green Mark Certified standard.

e) **Green Mark Incentive Scheme**

The \$20 million Green Mark Incentive Scheme was launched in 2006 to encourage building developers to achieve higher Green Mark ratings. New and retrofitted buildings with GFA above 5,000 m² that have achieved ratings of Green Mark Gold and above will be awarded monetary incentives.

Box 5.1: Green Mark Ratings



BCA Green Mark is a green building rating system to evaluate a building for its environmental impact and performance and provides a comprehensive framework for assessing building performance and environmental friendliness. Buildings are awarded the BCA Green Mark based on five key criteria:

- a) Energy Efficiency
- b) Water Efficiency
- c) Site/Project Development & Management (Building Management & Operation for existing buildings)
- d) Good Indoor Environmental Quality & Environmental Protection
- e) Innovation

Under the Green Mark assessment system, points are awarded for incorporating environmentally-friendly features. The total number of points obtained indicates the environmental-friendliness of the building design.

The assessment process consists of an initial assessment leading to the award of the Green Mark. Subsequently, buildings are required to have triennial assessment. This is to ensure that the Green Mark building continues to be well maintained.

Green Mark Award Rating

Green Mark Points	Green Mark Rating
85 and above	Green Mark Platinum
80 to <85	Green Mark Gold ^{PLUS}
70 to <80	Green Mark Gold
50 to <70	Green Mark Certified

Apart from achieving the minimum points in each rating scale, the project has to meet all requirements, and score a minimum of 50 per cent of the points in each category, except the Innovation category.

f) **Public Sector taking the lead**

The public sector is taking the lead in moving towards environmental sustainability for its buildings. It aims to demonstrate the associated environmental and economic benefits and to set an example for the private sector. Buildings such as the National Library Building and the Environment Building have won the top ASEAN awards for energy efficient buildings in 2007.



National Library Building

Households

Households account for close to a fifth of the electricity consumed in Singapore. In a typical household, refrigeration and air-conditioning account for a large proportion of electricity consumption. Energy efficiency in the households sector can be improved by encouraging consumers to purchase energy efficient appliances and to adopt energy efficient habits. Some initiatives to educate households on their consumption habits include:

a) **Mandatory Energy Labelling Scheme**

Energy labels are labels affixed to appliances at the point of sale to describe their energy performance. These labels help consumers make informed choices about the products they buy so as to better manage their energy bills. They also encourage manufacturers to design products that achieve higher efficiency ratings. Beginning from 2008, all household refrigerators and air-conditioners that are sold in Singapore must be energy labelled. The E²PO will evaluate the introduction of minimum energy performance standards for other energy-intensive household appliances.

b) **Reducing Standby Power Consumption**

Modern appliances often consume power even when they are supposedly “off”. Appliances on standby can account for up to 10 per cent of typical household electricity consumption.³ NEA will step up efforts to inform and encourage households to completely switch off appliances that are not in use.

Apart from empowering consumers with energy efficiency know-how, it is also important to ensure that the living environment is energy efficient. From 2008 onwards, residential buildings with a GFA of 2,000 m² or more must comply with BCA’s Residential Envelope Transmittance Value (RETV) standard.⁴

³ IEA Factsheet on Standby Power Use and 1-Watt Plan .

⁴ RETV measures the heat gain through the external walls and windows of air-conditioned residential buildings.

CAPACITY BUILDING

Capacity building is an important component of Singapore's energy efficiency strategy. The following are some programmes and schemes that we have embarked on, and others that we plan to pursue:

a) **Singapore Certified Energy Manager (SCEM) Programme**

The SCEM Programme is the first of its kind to be introduced in the region and is recognised and endorsed by the US Association of Energy Engineers. Launched in 2006, the programme equips facility and building managers, engineers, technicians and others who intend to build their career as energy professionals, with the technical skills and competencies needed to manage energy services within their organisations. Going forward, the E²PO will promote greater participation in the SCEM programme to create a pool of expertise which companies can draw from when they want to appoint energy managers or to plan and implement energy efficiency measures.

b) **ESCO Accreditation Scheme**

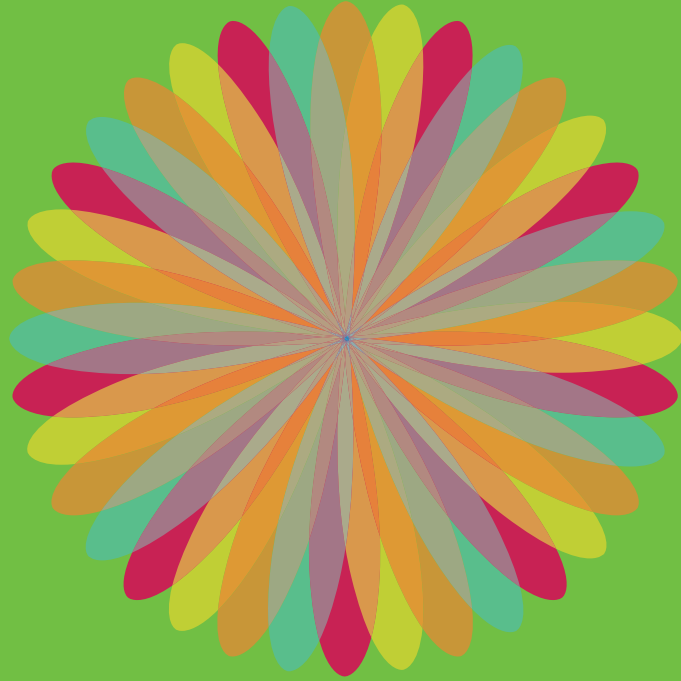
With support from NEA, NUS ESU administers an Energy Services Companies (ESCOs) Accreditation Scheme. The objective is to enhance the professionalism and quality of services offered. This will enhance confidence in the energy services sector and help promote the growth of the industry.

c) **Seminars and Conferences**

Over and above the formal training provided under the SCEM programme, E²PO will organise seminars and conferences to bring together stakeholders and experts in the field of energy efficiency to share knowledge and expertise in effective energy management.

CONCLUSION

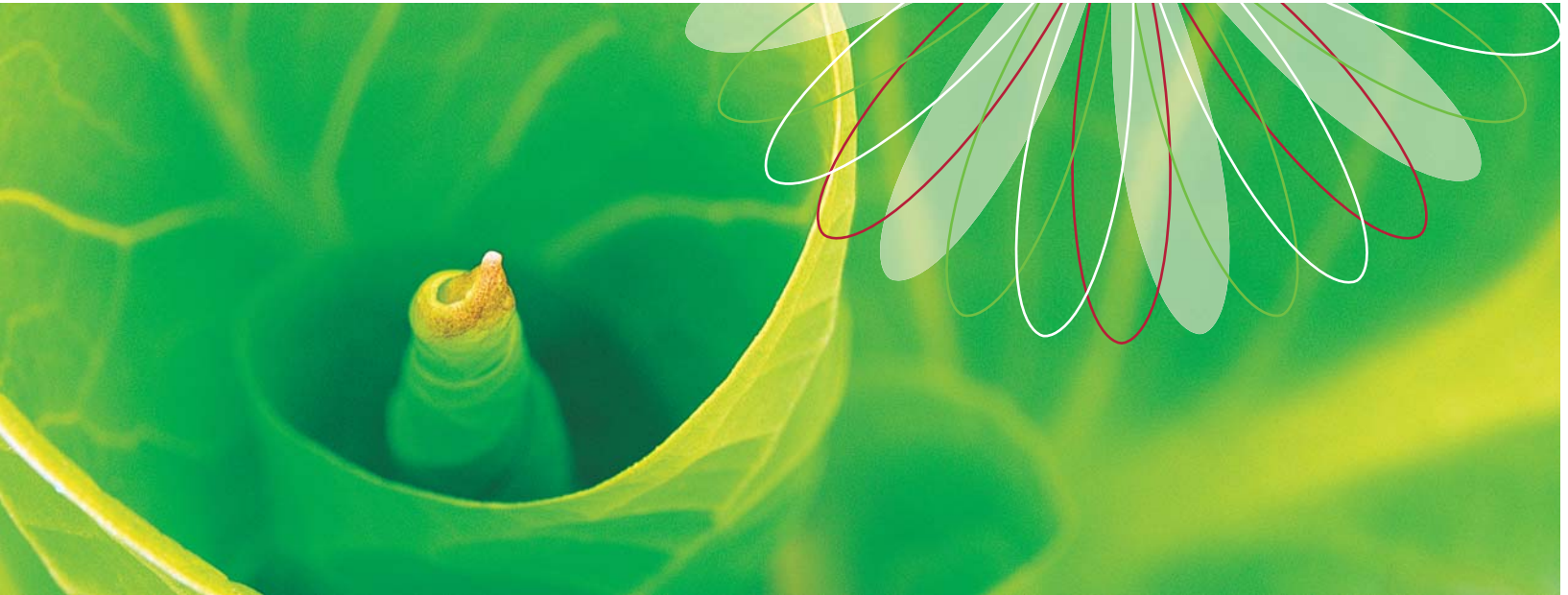
The Government will spearhead a sustained public awareness programme to promote energy efficient behaviour. Energy efficiency is one of the most practical ways in which every Singaporean can contribute towards saving energy and safeguarding the environment through simple lifestyle and habit changes.



energy and the environment

We need to manage the environmental impact of energy use. We have formulated a holistic response to climate change, focusing on four key areas of mitigation, vulnerability and adaptation, competency-building and public awareness. We will also safeguard our environment and air quality to ensure that Singapore remains a conducive home for Singaporeans and an attractive destination for investors, talents and tourists.

ENERGY AND THE ENVIRONMENT



Climate change is one of the biggest environmental challenges the world is facing today. Globally, there are observations of rising sea levels, warmer temperatures and more extreme weather events. The production, transmission and consumption of energy will have an impact on the environment, both in the immediate term due to the health impact from air pollution, and in the longer term due to the wide-ranging consequences of the rise in greenhouse gas (GHG) emissions.

ENERGY AND CLIMATE CHANGE

National Climate Change Strategy (NCCS)

Climate change is a global issue which requires a collective response from all countries. Singapore takes climate change action seriously, and we are a Party to both the UNFCCC and the Kyoto Protocol. Although Singapore only accounts for about 0.15 per cent of global CO₂ emissions, we will do our part to take domestic action to address climate change.

The Ministry of the Environment and Water Resources (MEWR) has formulated the National Climate Change Strategy (NCCS) which represents Singapore's comprehensive response to climate change. The NCCS outlines Singapore's efforts to adapt to climate change and mitigate our GHG emissions.¹

MEWR has also set up the National Climate Change Committee (N3C) since 2006, to engage the public, private and people sectors on climate change issues and policies, and gather feedback. It also provides a platform for key stakeholders to discuss climate change and energy efficiency issues.

Addressing Singapore's Vulnerability to Climate Change

By 2100, global temperatures are projected under the scenarios of the Fourth Assessment Report (AR4) of the IPCC to rise by 1.1 to 6.4 °C, and global sea levels by 18 to 59 cm compared to 1990 levels. To better understand the detailed effects and resulting impact of climate change on Singapore over the next century, NEA has commissioned a study on Singapore's vulnerability to climate change which is scheduled for completion in 2009.

The findings of the vulnerability study will enable Singapore to formulate measures to adapt to climate change. NEA will continue to work closely with other agencies to monitor and manage Singapore's vulnerability to climate change.

¹ More details on the NCCS can be accessed at www.mewr.gov.sg/nccs

Mitigating Singapore's GHG Emissions

Our GHG emissions are mostly carbon emissions arising from our energy usage, unlike agriculture-based economies where methane is a significant contributor. The two key measures of mitigating GHG emissions are to use less carbon-intensive fuels (e.g. natural gas or renewable energy), and to improve energy efficiency.

In terms of using less carbon-intensive fuels, our power generation companies have switched from using fuel oil to natural gas. Singapore is also one of the few countries in the world that incinerates almost all its waste, generating electricity in the process and minimising the amount of waste dumped into the landfills. As a result, Singapore's Semakau Landfill generates negligible amounts of methane, unlike landfills in other countries. Since 2000, Singapore's waste-to-energy plants have been contributing about 2 to 3 per cent of our power supply.

Improving our energy efficiency represents the key thrust of our actions on GHG emissions within the NCCS. As the lead agency on energy conservation and efficiency, NEA has worked with other agencies to develop a holistic energy efficiency plan for Singapore.



Semakau Landfill

ENERGY AND AIR QUALITY

Air Quality and Economic Competitiveness

Fossil fuels are the main source of energy in our economy, and their use results in air pollutants such as particulate matter (PM). Maintaining good air quality safeguards the health of our people, minimising the healthcare costs and productivity loss associated with air pollution. Good air quality also contributes towards a quality living environment, and helps to attract talents, investors and tourists.

However, controlling air pollution often means additional costs to our industries and transport sector. We therefore need to achieve the right balance of air pollution control measures to maintain Singapore's overall economic competitiveness, and protect the health and well-being of our population. Most of our energy needs are met with imported fossil fuels. While we prefer the use of cleaner fuels and technologies to reduce air pollution, we have to be mindful of the need to diversify our fuel supplies in order to maintain energy security, and not be too dependent on a single source of energy.

Pollutants of Concern

We have long applied strict environmental standards to industries and vehicles. As a result, Singapore's ambient air quality generally compares well to major cities in developed countries for most pollutants. Table 6.1 summarises how our ambient levels of major air pollutants compare to the USEPA standards. Except for PM 2.5, all other air pollutants are well within these standards.

Sulphur dioxide (SO₂) is another pollutant of concern, although our emission levels are within international standards. In Singapore, the main sources of SO₂ emissions are oil refineries and oil-fired power plants. As our energy-intensive sectors grow, we will continue to monitor and to manage these pollutants to safeguard public health.

	USEPA Standard	2002	2003	2004	2005	2006
Sulphur dioxide (SO ₂) annual mean (µg/m ³)	80	18	15	14	14	11
Nitrogen dioxide (NO ₂) annual mean (µg/m ³)	100	27	24	26	25	24
Carbon monoxide (CO) 8-hr mean (mg/m ³) 2 nd Maximum	10	2.8	3.1	2.8	2.4	2.6
Ozone (O ₃) 4 th Highest Daily Maximum 8-hr mean (µg/m ³)	157	114	108	143	155	127
PM 10 annual mean (µg/m ³)	50	31	28	31	30	33
PM 2.5 annual mean (µg/m ³)	15	23	19	21	21	23

Source: NEA

Policies and Measures

To manage air pollution, our policies and measures include:

Emissions from Stationary Sources

Emission concentration limits for various air pollutants, based on international standards (e.g. from USEPA) have been set for factories. NEA adopts a strategy of co-regulation, whereby companies are required to test their own emissions, with NEA carrying out additional random checks to ensure that the companies stay within the regulated limits.

The overall level of SO₂ emitted by the major emitters such as oil refineries and petrochemical plants are capped. This is to ensure that the ambient levels of SO₂ are within the acceptable level even as the industrial sector continues to expand.

The control of SO₂ emissions from other industries in Singapore is mainly done through limiting the sulphur content of fuel used. Furthermore, we have also put in place infrastructure such that power stations and industries on Jurong Island and Tuas Industrial Estate to use natural gas, which has a negligible amount of sulphur, instead of fuel oil for their processes.

Vehicular Emissions

In Singapore, strict management of vehicular emissions has limited the contribution of vehicles to air pollution. Diesel vehicles account for about 50 per cent of our ambient PM 2.5 emissions, but only about 1 per cent of SO₂ emissions.

Vehicle emission standards are specified to limit ambient air levels of carbon monoxide (CO), hydrocarbons, oxides of nitrogen (NO_x) and PM. To reduce PM 2.5 emissions from diesel vehicles, Euro IV standards for new diesel vehicles have been adopted since October 2006. Table 6.2 shows the emission standards (and their implementation dates) for different vehicle types.

In addition to emission standards for new vehicles, all existing diesel vehicles undergo compulsory periodic inspections (which include the Chassis Dynamometer Smoke Test) to ensure that such vehicles are roadworthy and meet smoke emission requirements. The amount of lead and sulphur in vehicle fuels have been gradually reduced over the years (see Tables 6.3 and 6.4).

NEA and LTA also promote the use of cleaner vehicles (such as petrol-electric hybrid and CNG vehicles) through the Green Vehicle Rebate (GVR). NEA has also provided funding to help interested private sector operators set up CNG refuelling stations.

Table 6.2: Implementation Dates for Emission Standards

Vehicle Type	Emission Standard	Implementation Date
Petrol vehicles	EURO II	1 January 2001
Diesel vehicles	EURO II	1 January 2001
	EURO IV	1 October 2006
Motorcycles/scooters	97/24/EC	1 July 2003

Table 6.3: Reduction of Lead in Petrol

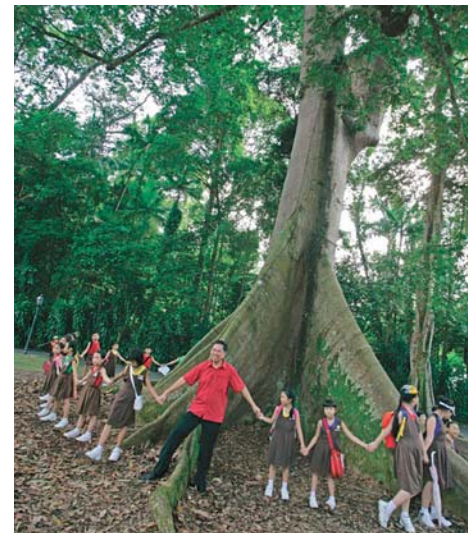
Effective from	Maximum Permissible Lead Content (gram/litre)
Before July 1981	0.8 g/l
July 1981	0.6 g/l
January 1983	0.4 g/l
June 1987	0.15 g/l
January 1991	Unleaded petrol introduced
July 1998	Leaded petrol phased out

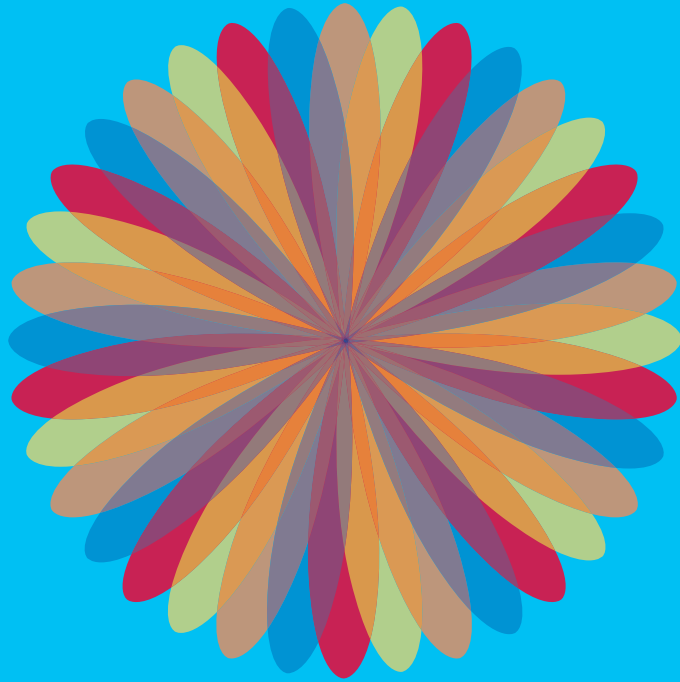
Table 6.4: Reduction of Sulphur in Diesel

Effective from	Maximum Permissible Sulphur Content (per cent by weight)
Before July 1996	0.5 per cent
July 1996	0.3 per cent
March 1999	0.05 per cent
December 2005	0.005 per cent

CONCLUSION

As a small island state, Singapore is not spared from the effects of climate change such as warmer temperatures and rising sea levels. To help address this challenge and its potential impact on our society, we have drawn up the NCCS, a comprehensive and holistic response to climate change focusing on four key areas, namely, mitigation, vulnerability and adaptation, competency-building and public awareness. Singapore also participates actively in international climate change fora. We will continue to review and update our national climate change policies in line with international developments, improve our understanding of the science of climate change, and promote advances in technology. We will also safeguard our environment and air quality to ensure that Singapore remains a conducive home for Singaporeans, and an attractive destination for talents, investors and tourists.





growing our **energy** industry

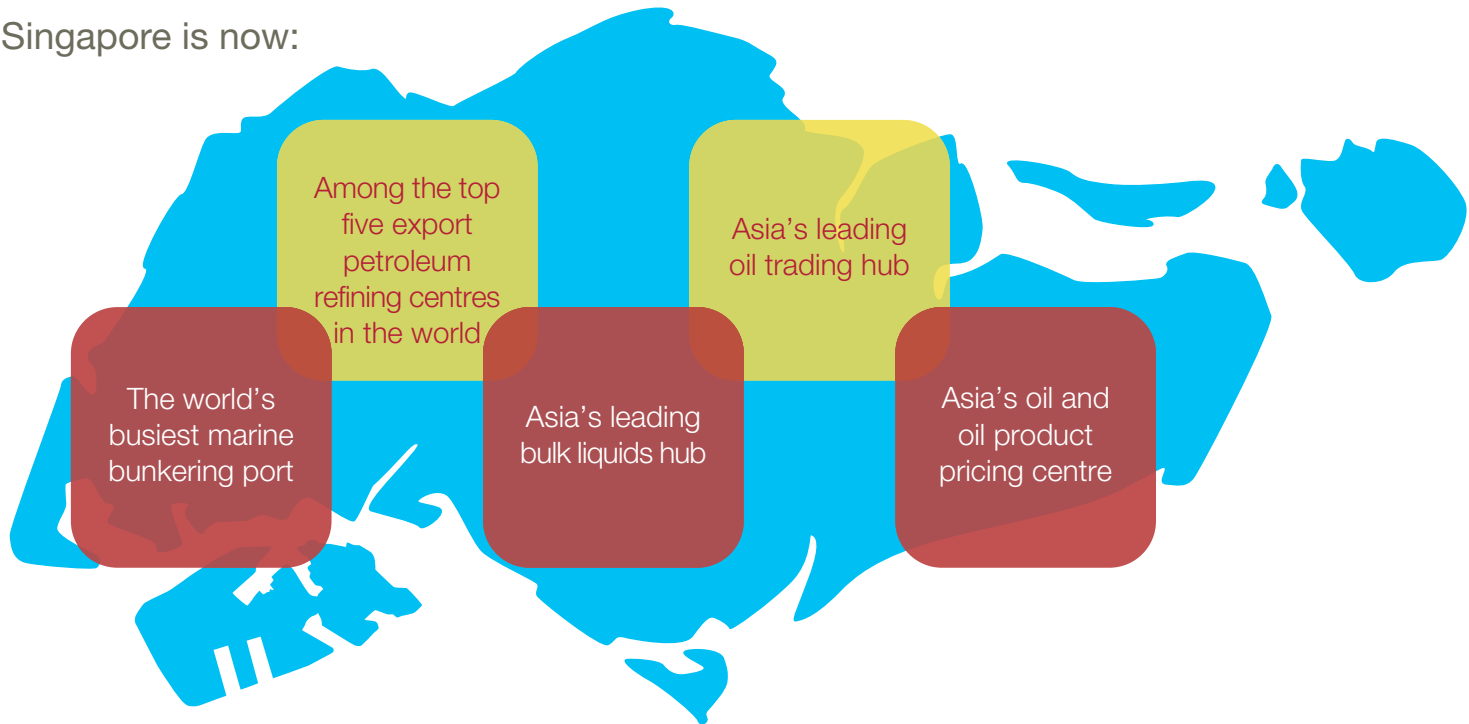
Our energy industry is unique. It flourished despite Singapore not having any indigenous energy resources. We will continue to develop our energy industry to turn the energy challenges into opportunities. In enhancing the vibrancy of our energy industry, our oil sector will continue to be the leading sector. The addition of new and emerging clean energy industries and energy services, and spin-offs in the supporting industries, will contribute towards a comprehensive energy industry cluster in Singapore.

GROWING OUR ENERGY INDUSTRY



Singapore's energy industry¹ is centred on oil refining and trading, with spin-offs into the chemicals, oil-field equipment manufacturing, shipping and logistics industries. Our oil industry has its roots in the 1890s when companies such as Shell and Standard Oil located their kerosene trading operations here. The first oil refinery in Singapore began operations in 1961. From those humble beginnings, the oil refining and trading industry has grown tremendously and contributed a substantial 4.5 per cent to Singapore's gross domestic product (GDP) in 2006.

Singapore is now:



Our energy industry is unique. It has flourished despite Singapore's lack of significant indigenous energy resources. Our strategic location on the major sea lanes between the Indian and Pacific Oceans, together with our deep-water harbours, has positioned us as a favourable transit point between the Middle East and South Asia, and East Asia. Over the years, we have also taken forward-looking initiatives to ensure that the necessary physical infrastructure is available to support the industry's growth. These include the development of Jurong Island as a petrochemicals hub, and the construction of the Jurong Rock Cavern (JRC)² to increase our oil storage capacity.

For the oil market, the Government takes a pro-business, non-interventionist approach to minimise investment risks. We have also put in place specific programmes to promote oil trading such as the Global Trader Programme (GTP), where qualifying companies are awarded a concessionary corporate tax rate on their offshore trading income.

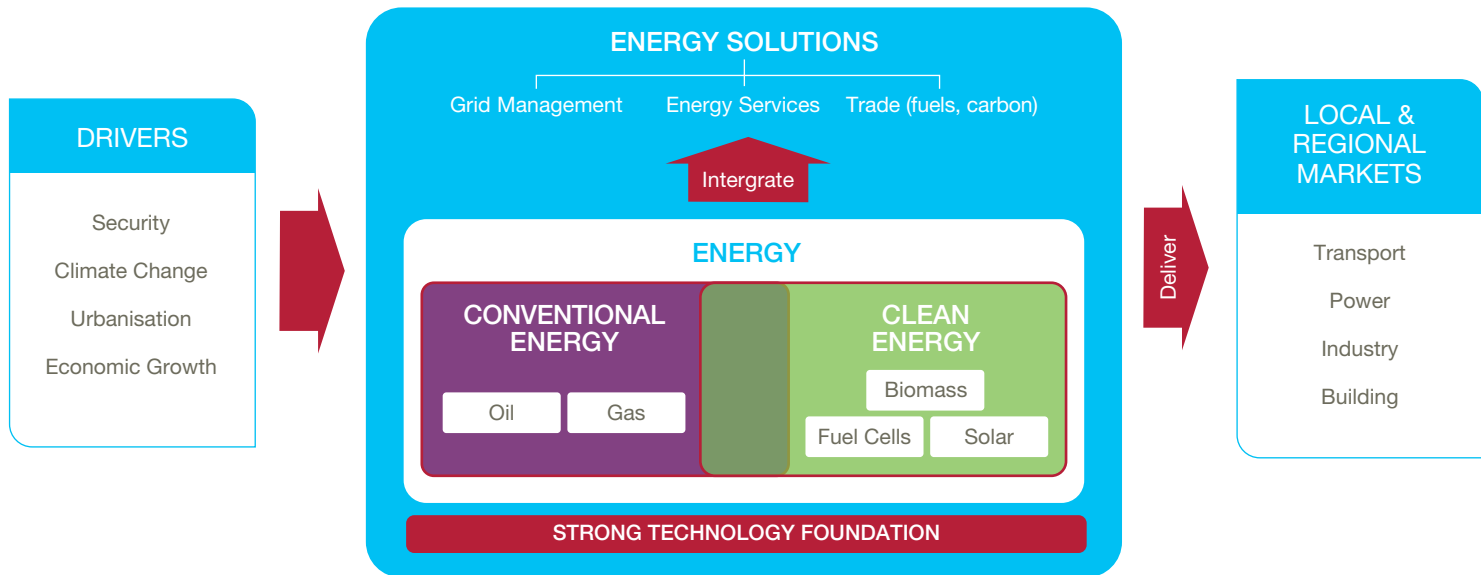


Jurong Island houses world-scale oil and chemical plants coupled with integrated logistics infrastructure to optimise efficiency

¹ For this Chapter, our focus is on developing the export-oriented energy industry and excludes the domestic distribution and retail of energy products such as electricity, transport fuels and town gas.

² The JRC is an underground oil storage complex to be built at subterranean depths beneath the seabed off Jurong Island. It has a potential storage capacity of about 3 million cubic metres and can be used to store liquid hydrocarbons like crude oil, condensates and diesel oil. Phase 1 of JRC will have a storage capacity of about 1.5 million cubic metres. Development works on the cavern began in late 2006 and the first cavern is expected to be ready for use in 2010.

Chart 7.1: Developing a Comprehensive Energy Industry Cluster



Moving forward, our oil industry will remain a key sector of our economy. We are also aware of exciting opportunities in new growth areas such as solar power, fuel cells, biofuels and energy management solutions. Our approach is hence to develop the industry centred on providing holistic energy solutions, through building on our existing strengths and strong technology foundation [see Chart 7.1]. We aim to increase the value-added from Singapore's energy industry from \$20 billion to \$34 billion by 2015, and to triple the employment in this sector from 5,700 to 15,300.

STRATEGY 1: EXPAND REFINING BASE

The tripling of oil prices since 1999 has been the result of strong demand from a buoyant global economy, especially in China and the rest of Asia. China alone is already the second largest oil consumer in the world, and is expected to double its oil consumption over the next 20 years. Asia as a whole is expected to consume over 30 per cent of the world's total oil by 2030.³

Over the past three decades, the global economy has become less energy-intensive, and is better able to cope with higher energy costs. Combined with limited production capacities and continued supply-side risks due to political instability and natural disasters, a sustained period of higher oil prices is likely to continue. Against this backdrop of oil demand and supply trends, global refining capacity is expected to increase by 30 million barrels per day by 2030.

As a result, there is considerable potential for growing Singapore's oil refining capacity beyond the current 1.3 million barrels per day. Refining operations are knowledge- and technology-intensive, and can create employment in the chemical, process, electrical and environmental engineering fields. We will promote the expansion and upgrading of our existing refineries and attract greenfield investments to maintain Singapore's share of global refining capacity. This will ensure that there is a critical volume of export-oriented refining throughput to create the liquidity needed to anchor oil trading and price discovery activities in Singapore.

³ Source: EIA International Energy Outlook 2007.

STRATEGY 2: EXTEND BEYOND OIL TRADING TO ENERGY TRADING

Energy trading is an important component in growing our energy industry, as it establishes the linkage between producers, intermediaries and consumers. Economic and physical connectivity ensure continued access to energy sources and markets.

Singapore accounts for between 15 to 20 per cent of the world's physical oil trade, with an annual value above US\$300 billion. We are also the world's largest bunker fuel centre with more than 28 million tonnes of bunkers uplifted from Singapore waters in 2006. Leveraging on our experience in oil trading, we will increase the range of energy products traded in Singapore. These include:

LNG Trading

LNG technology has made long haul transportation of natural gas viable, and is helping to develop a global market for this fossil fuel. However, over the next five years, natural gas supply is expected to be tight due to delays in upstream projects and rising demand in Asia. As a result, even with LNG, supply contracts have been mainly structured as long-term agreements. Nevertheless, the tightness in the market is expected to ease after 2012. According to IEA's projections, natural gas is expected to meet 23 per cent of total global energy demand in 2030, up from 21 per cent in 2004. There will be opportunities in LNG trading, as LNG buyers would start to purchase from the spot market to meet some of their needs.

Given Singapore's decision to import LNG for our domestic needs, we can capitalise on the LNG infrastructure and our strengths in oil trading to promote Singapore as a centre for LNG trading in Asia. For a start, we have introduced a concessionary tax rate of 5 per cent on LNG trading income for companies under the GTP in May 2007.

Biofuels Trading

The potential demand for biodiesel in Asia could reach 4 to 6 million tonnes by 2010 and 14 to 16 million tonnes globally.⁴ One advantage for Singapore in developing biofuels trading is that our production capacity is geared for overseas markets. Based on projects in the pipeline, Singapore could have an annual production capacity of 1 million tonnes of biodiesel by 2010, and 3 million tonnes by 2015.

We also aim to enable price discovery for biodiesel in Singapore and explore the introduction of a derivative contract for biodiesel. These activities could then be extended to bioethanol if bioethanol production or usage takes off in Asia.

Carbon Trading and Services

The Kyoto Protocol has created international markets for the pricing and trading of carbon emission allowances or credits. The international carbon market grew in value to an estimated US\$30 billion in 2006. Clean Development Mechanism (CDM) projects alone grew sharply to a value of about US\$5 billion in 2006.⁵ Taking the transacted price range of Carbon Emissions Reductions (CERs) in the past 12 months (€5 to €3 per tonne, or US\$7.20 to US\$18.60 per tonne), the 400 million CERs traded from these CDM projects have a tradable value of between €2 billion to €5.2 billion (US\$2.9 billion to US\$7.4 billion).⁶

In Singapore, several private sector players in different parts of the carbon value chain have expressed interest to use Singapore as a base to support the development of CDM projects for local and regional markets. We have set up a Renewable Energy Exchange that aims to bring together investors looking for bankable renewable energy CDM projects and developers looking for financing. Asia Carbon also operates an online auction platform for emission credits, the first of its kind in the world. In addition, there are a number of premier carbon-related conferences and events being held in Singapore such as Carbon Forum Asia. These events would help to raise the awareness of companies in the region to explore emission-reduction opportunities.

As Singapore's Designated National Authority, NEA ensures that CDM projects support sustainable development in Singapore. NEA and IE Singapore are also working together to promote CDM and to provide assistance to private sector players who are keen to develop CDM projects. In parallel, we aim to provide a conducive business environment for the trading of emission credits. In May 2007, IE Singapore announced the inclusion of emission credits as a qualifying product under the GTP.

⁴ Source: Rabobank

⁵ Source: International Emissions Trading Association (IETA)

⁶ Source: Asia Carbon Group

STRATEGY 3: GROW THE CLEAN ENERGY SECTOR

The convergence of high oil prices, climate change concerns and energy security interests have fostered a surge of interest in renewable and clean energy technologies such as solar, wind, fuel cells and biofuels. The global market for these four clean energy technologies is projected to quadruple from US\$55 billion in 2006 to more than US\$220 billion by 2016.⁷

Clean energy is part of the broader clean technology trend that has attracted significant investment and corporate interest in recent years.⁸ In 2006, the overall venture and private equity investment flowing into the clean energy sector increased by 67 per cent to US\$18.1 billion from US\$10.8 billion in 2005.⁹ This is third only to the information technology and biomedical sectors. Clean energy dominates with 45 per cent of the total clean technologies investments in North America and 75 per cent in Europe.

In March 2007, the Research, Innovation and Enterprise Council (RIEC) chaired by Singapore's Prime Minister, endorsed clean energy as a key growth area for Singapore with the target of generating \$1.7 billion value-added and 7,000 jobs by 2015.

Clean energy is a sector driven by technological innovations. It builds on advancements in other sectors such as electrical engineering, mechanical engineering, material science, chemical engineering, nanotechnology and even biotechnology, and applies these to energy generation and the development of products and systems to enhance energy efficiency. R&D and test-bedding are thus important for the successful development of this sector.

Singapore has several advantages through which it can capture opportunities in clean energy, specifically in the four focus areas of solar, fuel cells, biofuels and energy efficiency solutions. Energy efficiency solutions will be discussed under Strategy IV.



(i) Solar

The global solar industry was a US\$15.6 billion market in 2006 and is projected to continue to grow rapidly at 30 to 40 per cent annually for the next few years.¹⁰ For manufacturing, our experience with the semiconductor industry provides Singapore with the industrial infrastructure and a workforce familiar with silicon technologies which is the dominant material used in photovoltaics (PV). In addition, our manufacturing know-how, including process automation expertise, lends itself well to the need of the solar industry to scale-up and reduce unit costs in order to meet rapidly expanding global demand.

⁷ Source: Clean Edge, *Clean Energy Trends*, March 2007

⁸ Clean technology is commonly taken to include any knowledge-based energy product or service that improves operational performance, productivity or efficiency; while reducing costs, inputs, energy consumption, waste or pollution.

⁹ Source: *New Energy Finance*, *Cleaning up 2007*, August 2007

¹⁰ Source: Clean Edge, *Clean Energy Trends*, March 2007

From the market standpoint, Singapore is conveniently located to serve the Asian sunbelt which has about 50 per cent more solar radiation than the temperate countries. Singapore's urban landscape provides opportunities to develop capabilities in system integration and building integrated PV which can be exported to the region. Singapore is also well positioned to serve the off-grid market in countries such as India, Indonesia, the Philippines and Sri Lanka, that collectively have an estimated one billion people without access to electricity. When solar-generated electricity reaches price parity with retail electricity tariffs, the solar market in the Asian sunbelt is expected to experience another quantum leap. This may happen in about 5 to 15 years' time, depending on the location.

We will endeavour to grow this new sector. Recent developments that have given a boost to our efforts include the establishment of the world's largest solar manufacturing complex in Singapore by Norway's Renewable Energy Corporation (REC), solar panel manufacturing investments by Solar Energy Power and Eco-Solar, and the decision by leading solar and clean energy companies such as SolarWorld and Conergy to set up their Asia-Pacific headquarters in Singapore.

(ii) Fuel Cells

Fuel cells are electrochemical energy conversion devices that can efficiently and cleanly harness hydrogen which may be produced from fossil fuel and alternative energy sources. Many renewable energy sources such as wind and solar generate power intermittently. Hydrogen is promising as an intermediate energy storage for such renewable energy sources and in turn, can be used to power fuel cells. While fuel cell technology has attracted much attention over the years, there remains a lot of development work before mass-scale commercialisation can take place successfully. For Singapore, our clean energy aspirations as well as capabilities in managing complex industrial equipment manufacturing put us in good stead to capture future opportunities in this area.

(iii) Biofuels

Biofuels, which include biodiesel and bioethanol, refer to fuels derived from bio-based sources. They have gained prominence largely due to their immediate viability as a blend or substitute to petroleum fuels used in land transportation, and their perceived benefits in terms of energy security and carbon reductions.

Singapore's proximity and good logistics connectivity to Malaysia and Indonesia, which account for 80 per cent of the world's palm oil supply, has already attracted investments from Peter Cremer, Continental and Natural Fuels since 2005. Their investments will yield a biodiesel production capacity of 650,000 tonnes per annum on Jurong Island. These plants will utilise first generation trans-esterification technology that also generate methyl-esters and glycerin by-products, which can in turn generate desirable downstream opportunities and provide feedstock for the chemicals industry.

However, demand for biofuels derived from food crops such as corn, sugar cane and palm oil has driven up the price of food products, and this may not be sustainable in the long term. Moreover, given that much of the international interest in biofuels stems from the idea that they reduce the amount of carbon produced by fuels (as the crops absorb CO₂ while they are growing), biofuels will need to come from sustainable sources to maintain this reputation. Going forward, we will encourage projects involving second generation biofuels that are produced from non-food crops such as grass, wood chips and plant waste, and/or by alternative technologies that produce higher grade biofuels compared to the first generation. Commercial plants for these advanced biofuels are just coming on-stream in Europe. Equally importantly, second generation biofuels are also expected to offer a better energy balance.¹¹

¹¹ Energy balance is the ratio of energy yielded by a given amount of biofuels to the energy needed to produce it. Bioethanol from corn is estimated to be 1.3 whilst that from sugar cane is 8.0.

STRATEGY 4 — HELP SUSTAINABLE ENERGY SOLUTIONS PROVIDERS EXPAND INTO THE REGION

Rapid urbanisation and the formation of mega-cities, especially in Asia, have heightened concerns over high energy costs, disruptions in energy supply and unstable electricity grids. There is also rising socio-political awareness of climate change. There will thus be an increasing demand for the development and supply of sustainable energy solutions applicable in urban environments.

Singapore is well-positioned to capitalise on this market opportunity, given our global reputation as a clean and green city. Our “Four Taps Strategy”¹² and our integrated approach to the development of water solutions have placed Singapore on the global map for the water industry. We desire to do likewise with energy solutions. This is a big field that can range from the development and use of sensors, monitoring and control systems to conserve energy use in industrial settings, to the design of buildings that reduce the need for artificial light, heating or cooling. For a start, we will focus on two key areas:

(i) Grid management

The advent of intermittent sources of energy and distributed generation will create future demand for sophisticated systems to integrate these sources into the electricity grid safely and reliably. Building on Singapore’s power supply reliability and liberalised electricity market status, we intend to pursue the development of these solutions. We are installing a microgrid on Jurong Island, as part of the SINERGY Centre for the

purpose of test-bedding new technologies such as solar PV systems and fuel cells. We aim to deploy such technologies on a commercial scale in the future. Such know-how would also be exportable.

(ii) Energy consultancy and engineering services

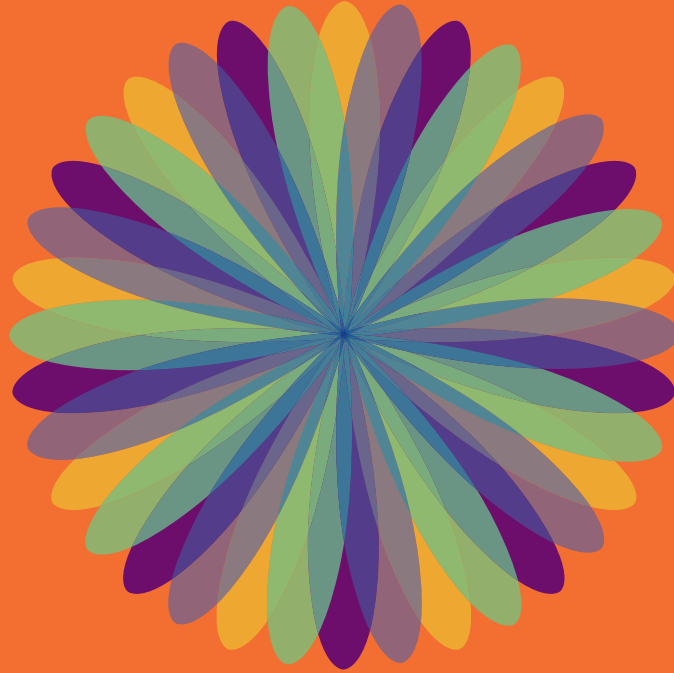
Energy efficiency is a practical and tenable option for reducing energy utilisation and cost, safeguarding the environment and enhancing energy security. There are significant opportunities for energy services companies (ESCOs) that provide consultancy and engineering services related to energy conservation. As Singapore develops best practices in energy efficiency across our industrial, building and other sectors, we will also develop a pool of ESCOs with good track records that will be able to export their services.



CONCLUSION

We aim to increase the vibrancy of our energy industry with the above strategies. While the oil sector continues to be the leading sector, the addition of new and emerging clean energy industries and energy services, and spin-offs in supporting industries, will contribute to a comprehensive energy industry cluster in Singapore.

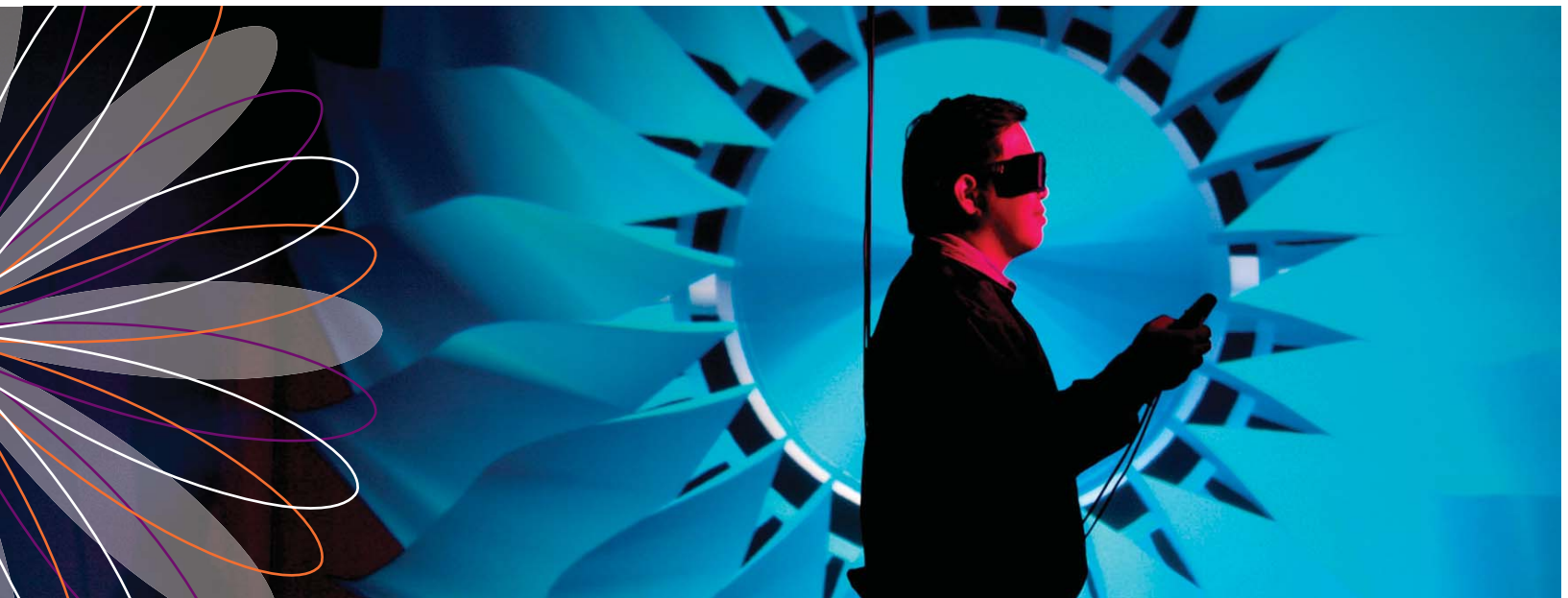
¹² The Four Taps are (i) Local Catchment, (ii) Imported Water, (iii) Desalinated Water and (iv) Reclaimed Water.



achieving our **energy** goals through r&d

The development of clean energy technologies and sustainable energy solutions will not only help to improve Singapore's own urban environment but also position us favourably to capture the new economic opportunities that are emerging. By leveraging on existing strengths, building new capabilities in clean energy and integrating these technologies at a systems level, we aim to develop unique energy applications for ourselves, the region and beyond.

ACHIEVING OUR ENERGY GOALS THROUGH R&D



The development of new energy technologies is an important component in the response to the challenges of energy security and climate change. These technologies could provide the world with more efficient energy systems, as well as cleaner and more varied energy sources.

Given Singapore's lack of natural resources, the application of new and emerging technologies will play an even greater role in supporting our energy diversification and environmental sustainability efforts. Furthermore, a strong technology under-girding would be crucial to the success of our efforts to build the energy industry.

CURRENT ENERGY R&D EFFORTS

There are already a number of energy research activities taking place in our research institutes, institutes of higher learning and the private sector. These initiatives have largely been driven by the research interests of the organisations concerned. Examples include research on novel materials for solar cells by the Institute of Materials Research and Engineering (IMRE), NUS and NTU. In addition, the Institute of Chemical Engineering Sciences (ICES) has process R&D expertise to support the petroleum refining and chemicals industries, and has also started programmes to develop catalysts and novel processes for cellulosic ethanol conversion.

Energy R&D in the private sector include Grenzone's development of rural solar applications; and Solar2D's study on fluorescent dyes that aims to increase the bandwidth of radiation absorbed by different semiconductor materials, and improve efficiency in solar modules. Another example is Vestas, the world's largest supplier of wind power systems, which is setting up a \$500 million R&D Centre in Singapore with 150 research scientists and engineers.

There are also a number of programmes in fuel cell R&D. Nanyang Polytechnic and Temasek Polytechnic are embarking on their own programmes, with the latter planning to invest over \$5 million to establish a Fuel Cell Application Centre to engage start-ups for collaborative R&D. In industry, Rolls-Royce embarked on a \$10 million 3-year joint research programme with A*STAR and ceramics supplier, Advanced Materials Technologies, to develop automated fuel cell manufacturing technology.

Moving forward, we will be intensifying our efforts on energy R&D to develop sustainable energy solutions for both domestic applications and the global market. There is a myriad of technologies that we can pursue. However, given Singapore's limited resources, it is not possible or practical to invest in every field. We need to be focused on areas that play to our strengths, so as to increase our chances of success.

CHARTING OUR TECHNOLOGY FUTURE — STRATEGIC INITIATIVES

We have adopted a forward-looking and holistic approach that includes building energy R&D infrastructure and test-bedding platforms, establishing energy R&D programmes, and putting strategic energy R&D funding in place. The key initiatives are:

(i) Singapore Initiative on New Energy Technologies (SINERGY) Centre

SINERGY Centre will be established to provide the technical infrastructure for the development of clean energy technologies and sustainable energy solutions. It will consist of the following:

- a) **Microgrid**
This will enable researchers and companies to test-bed novel power generating, storage, and integrated power/thermal systems and study their performance in a grid environment. These systems can be harnessed to work in concert with one another in main grid-isolated (islanded) mode as well as in main grid-paralleled operations. They can also utilise a variety of conventional and alternative fuels such as natural gas, biofuels and hydrogen.
- b) **Command & Control Facility**
It will serve as the control centre for the assets on the microgrid and provide access to other systems and assets operated by collaborators. The facility will have technology to enable real time information exchange, remote and intelligent monitoring, diagnosis, decision making, control and management. Such capabilities are important for the operation of physical energy and power systems; and for complex energy markets.

SINERGY Centre will work with independently-funded research groups from both the public sector and industry. Through the research collaborations, the centre is expected to develop in-house expertise in systems integration, testing and evaluation of technologies. In time, the centre may be able to offer this expertise in the form of consultancy services to address issues such as grid management, energy efficiency and fuel management, both locally and overseas.

We intend for SINERGY Centre to interact regularly with companies in the clean energy and sustainable energy solutions sectors. R&D laboratory and incubation space will be made available for companies developing products and solutions for the power industry, such as in power electronics, conversion devices, materials, storage and portable power systems, advanced cooling and dehumidification technologies, sensors, monitoring and control devices. In addition, the centre will explore the feasibility of working with venture capitalists and other firms to provide commercialisation support for the technologies developed.

Besides industry, the centre will also provide the technical know-how to support Government agencies in their work on energy policies and regulations. This will allow for informed, innovative and forward-looking policies.

(ii) Energy Technology R&D Programme

A*STAR has established an Energy Technology R&D Programme as the focal point to coordinate, integrate and expand existing efforts and capabilities in fuel cells, alternative fuels (including biofuels and hydrogen) and next-generation solar PV technologies.

In addition, we will identify and develop new research thrusts under this programme, which will be relevant to Singapore's developmental strategies for the energy industry and in areas where Singapore can be internationally competitive. In particular, we are starting a new research thrust on "Intelligent Energy Distribution Systems" that will utilise SINERGY Centre's unique infrastructure to advance the development of energy distribution systems and technologies for the future.

The programme will also seek to develop the necessary talent by attracting renowned scientists and technology leaders to lead research groups under the programme; and training research manpower to support industry needs. It will foster research partnerships with local and overseas research organisations to leverage on their strengths and reputation.



(iii) Clean Energy Research and Test-bedding Programme (CERT)

CERT was launched in August 2007 to stimulate research in the application of clean energy in Singapore. A \$17 million fund has been allocated to support test-bedding projects involving the buildings and facilities of various government agencies. CERT will complement the \$50 million MND Research Fund for the Built Environment where R&D in green building technologies is a focus area.

Singapore Polytechnic and the NUS have been selected as the lead R&D organisations for CERT. National Parks Board's Gardens by the Bay, PUB's Marina Barrage and Singapore Polytechnic's campus will be the test-bedding sites in this first phase of CERT. The second phase, to start by January 2008, will include BCA's Zero-Energy Building and HDB's Eco-Precinct @ Punggol.



Artist's impression of BCA's Zero Energy Building

By conducting research and test-bedding in Singapore through CERT, Singapore-based companies and institutes of higher learning will be able to build competencies in system integration, installation, architectural design, urban planning, green building technologies, energy efficiency and building integrated PV. Through fine-tuning their technologies and building up their track records, these companies can leverage on Singapore as a launchpad to export their products and services internationally.

In addition, CERT will help the Government in studying the feasibility of distributed generation as a possible component in the strategy for energy diversification.

(iv) NRF Clean Energy Programme

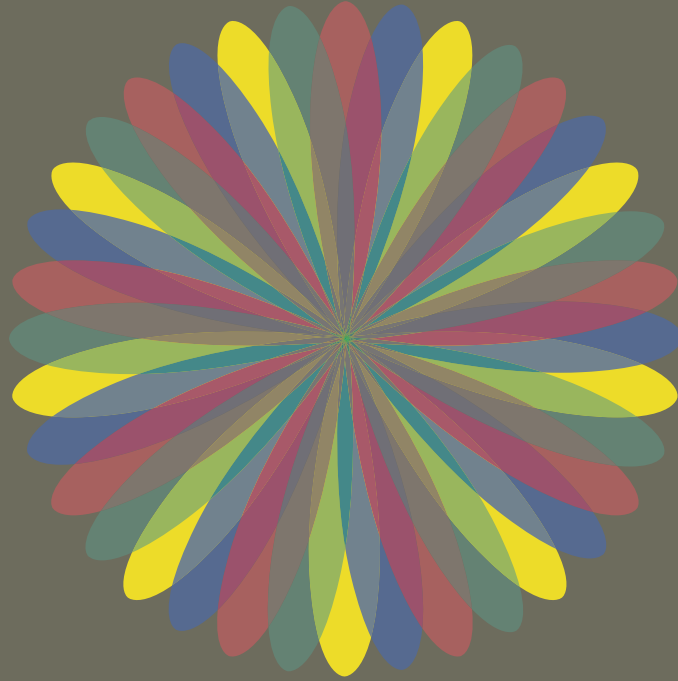
The NRF has set aside \$170 million to boost our clean energy R&D with a focus on solar research as a start. The funding will be used to:

- a) Provide competitive grants for clean energy projects undertaken by both the public and private sectors;
- b) Support the establishment of world-class clean energy R&D centres to create the critical mass in innovation capacity and establish global linkages to other centres of excellence; and
- c) Incubate clean energy start-up companies by helping them to commercialise their technologies.



CONCLUSION

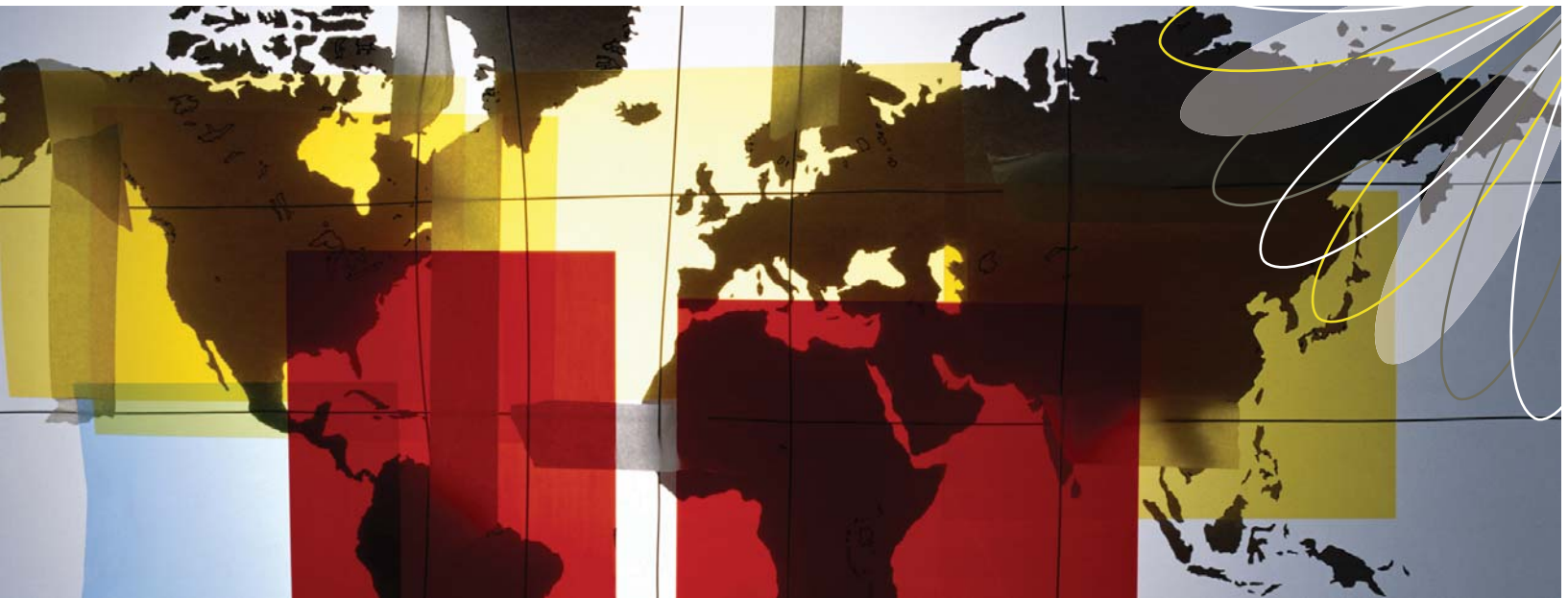
By keeping a strategic focus in our R&D initiatives, we will be able to generate the most impact from our limited resources. The development of clean energy technologies and sustainable energy solutions will not only help to improve Singapore's own urban environment but also position us favourably to capture the new economic opportunities that are emerging. By leveraging on existing strengths, building new capabilities in clean energy and integrating these technologies at a systems level, we aim to develop unique energy applications for ourselves, the region and beyond.



engaging our international **energy** partners

With countries growing increasingly interdependent on one another for their energy needs, it is important that while we pursue our own domestic energy policies, we also promote Singapore's key energy interests through various regional and international initiatives, in cooperation with our neighbours, and with our partners in key international fora.

ENGAGING OUR INTERNATIONAL ENERGY PARTNERS



With greater uncertainties in energy markets and countries paying closer attention to their energy security, the energy environment is undergoing profound changes that will pose new challenges and opportunities for Singapore. As a result, countries have become more interdependent on one another for their energy needs.

Singapore's external energy policy should therefore, not only involve its efforts at energy diversification, but also include efforts to promote regional and international cooperation to further Singapore's energy interests. The objectives of our external energy policy are three-fold:

OBJECTIVE 1: PROMOTE REGIONAL AND INTERNATIONAL ENERGY COOPERATION

Energy diversification is an important element of Singapore's efforts to enhance its energy security. To reduce our dependence on any one source of supply, Singapore will be exploring alternative sources and types of energy to meet future energy needs. In this regard, Singapore will continue to develop its links and enhance cooperation with the key energy players, such as energy producing countries and key industry majors, given that the relationships between them are also changing in fundamental ways.

Within the region, Singapore will also contribute to efforts to promote greater energy security through regional fora such as ASEAN, ASEAN+3, EAS and APEC. In particular, Singapore will work towards the long-term goal of promoting a regional energy market through regional energy projects like the ASEAN Power Grid (APG) and the Trans-ASEAN Gas Pipeline (TAGP). When realised, these two projects will provide a basis for the development of a regional energy trading market.

In addition to these efforts to develop regional energy markets, fora like ASEAN, EAS and APEC have also been paying greater attention to energy efficiency as a means to enhance energy security. For Singapore in particular, even as we develop and share our own technologies in energy efficiency, conservation and renewable energy at these regional fora with others, we have also been learning from countries like the United States, Japan and Germany, which possess the expertise and technological know-how in various fields of energy research and policy.

We will also dovetail our external energy policy with our external climate change policy. Singapore is cognisant of the need to balance our economic growth with environmental sustainability, especially given the recent attention on the effects of climate change. On this account, Singapore has been a Party to the UNFCCC since 1997 and we have acceded to the Kyoto Protocol in April 2006. We strongly support and

actively participate in climate change initiatives both within the UNFCCC framework and at other fora where the issue is being discussed. The Government has set up a Ministerial Committee on Climate Change chaired by Deputy Prime Minister Professor S Jayakumar to coordinate our efforts. As a relatively small energy consumer accounting for only 0.15 per cent of the world's CO₂ emissions, Singapore has been finding other innovative ways through which we can contribute meaningfully. Some of our efforts include working with other countries on R&D in renewable energy, and sharing our expertise in various fields of environmental management like water and waste management, sustainable city planning, and the preservation of greenery and biodiversity.

With growing interest in cleaner forms of energy, nuclear energy has re-emerged as an important alternative energy source. However, there remain concerns over its safety. Singapore, along with other ASEAN countries, will work towards establishing a Nuclear Energy Safety Sub-Sector Network (NES-SSN) to explore cooperation on nuclear safety issues within ASEAN. Similarly, APEC has also recognised that while nuclear energy can be a useful component in a member economy's energy mix, it also carries certain trans-boundary risks. We hope that the discussions on nuclear safety at APEC would reinforce our efforts to create a safe and secure environment for the peaceful development of civilian nuclear energy within ASEAN.



Opening Ceremony of 25th ASEAN Ministers on Energy Meeting on 23 August 2007 in Singapore



OBJECTIVE 2: PROMOTE SECURITY OF VITAL ENERGY SEA LANES IN THE REGION

The world's reliance on oil and gas from the Middle East will continue for the foreseeable future. Since a significant proportion of the oil and gas from the Middle East will have to be transported by sea to Asia and other regions, the bulk of these supplies must transit a series of maritime chokepoints, including the Straits of Malacca and Singapore (SOMS). As such, there are concerns that any impediment to these narrow sea lanes would cause a major disruption to the supply of energy.

For Singapore and East Asia, the SOMS is an integral part of the critical energy supply route from the Middle East to East and Southeast Asia. According to one estimate, 60 per cent of China's 6.9 million barrels, 90 per cent of Japan's 5.2 million barrels, and 80 per cent of Korea's 2.2 million barrels of imported oil per day pass through the SOMS from the Middle East.¹ With Asia's demand for oil and gas being fuelled further by economic development and population growth, maritime traffic transporting energy through the SOMS will increase. Singapore's fundamental strategic maritime interest therefore lies in the maintenance of the freedom of navigation through all regional waters and key sea lines of communications, with the SOMS being especially vital to us.

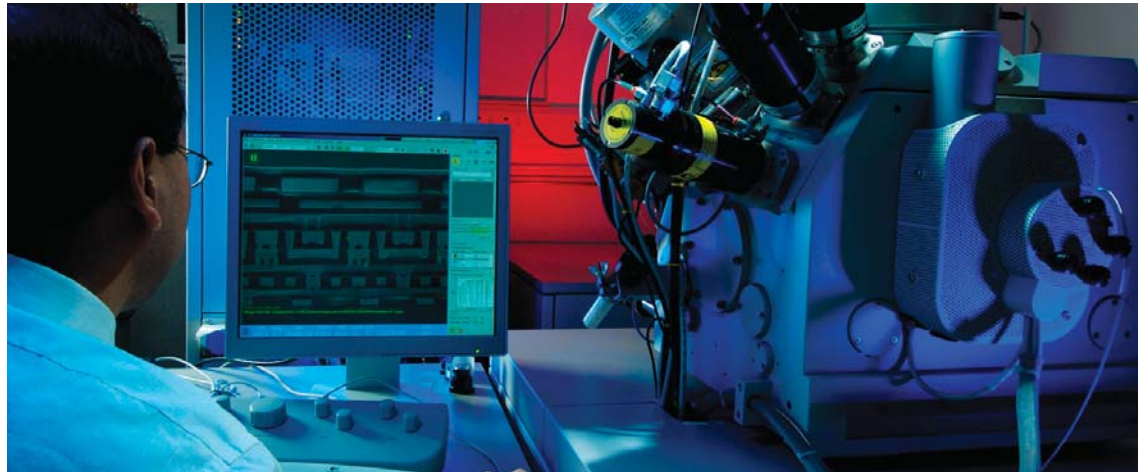
To secure our access and the freedom of navigation through the SOMS, the operational agencies of Singapore, Malaysia and Indonesia have undertaken various efforts to improve the security of the Straits. These ongoing efforts include the Malacca Straits Patrols as well as exercises under the Western Pacific Naval Symposium and the ASEAN Regional Forum. The Regional Cooperation Agreement on Combating Piracy and Armed Robbery Against Ships in Asia, which entered into force on 4 September 2006, is the first regional government-to-government agreement to promote cooperation against piracy and armed robbery in Asia. Its centrepiece is the Information Sharing Centre (ISC). Launched in Singapore on 28 November 2006, the ISC has been facilitating important information exchange among regional authorities to tackle incidents of piracy, and also to build up their capacity to implement more effective preventive measures. A recent landmark development was the establishment of the Cooperative Mechanism on 4 September 2007 at the Singapore Meeting on the SOMS. This Mechanism serves as a framework for user states to cooperate with the littoral states in enhancing the safety of navigation and environmental protection in the SOMS.

¹ Source: IEA, *World Energy Outlook 2006*.

OBJECTIVE 3: PROMOTE SINGAPORE AS A CENTRE OF ENERGY RESEARCH AND EXCELLENCE

With an uncertain global energy outlook and multi-faceted energy challenges facing Singapore, we will need to develop our own expertise and intellectual capabilities on energy-related issues. To this end, we have established the Energy Studies Institute (ESI), which will help promote greater awareness, dialogue and collaboration within the region through policy-oriented research and organising conferences, seminars and other platforms for information sharing. The key event will be the Singapore Energy Conference that will serve as a new platform to engage major energy players in the region on significant energy issues of the day.

Singapore will also strengthen our collaboration with various energy research institutes on energy R&D and the test-bedding of new energy technologies through agencies such as A*STAR and NRF. Our venture into energy research will not only position us favourably to capture the new economic opportunities that are emerging, but also help promote Singapore as an important centre for energy research.



CONCLUSION

Singapore's external energy strategies promote our key energy interests through various regional and international initiatives, in cooperation with our neighbours, and partners in key international fora. This will enable us to enhance our energy security, mitigate our geographical constraints and play our part in the region.

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ACRONYMS

APEC	Asia-Pacific Economic Cooperation	GVR	Green Vehicle Rebate	N3C	National Climate Change Committee
APG	ASEAN Power Grid	HDB	Housing and Development Board	OMV	Open Market Value
AR4	Fourth Assessment Report	IA	Investment Allowance	OPEC	Organisation of Petroleum Exporting Countries
ARF	Additional Registration Fee	ICAO	International Civil Aviation Organisation	NCCS	National Climate Change Strategy
ASEAN	Association of Southeast Asian Nations	ICES	Institute of Chemical Engineering Sciences	PM 2.5	Particulate matter finer than 2.5 microns
A*STAR	Agency for Science, Technology and Research	IEA	International Energy Agency	PM 10	Particulate matter finer than 10 microns
BCA	Building and Construction Authority	IE Singapore	International Enterprise Singapore	PNG	Piped natural gas
BP	British Petroleum	IETA	International Emissions Trading Association	PPM	Parts per million
CAGR	Compound annual growth rate	IMRE	Institute of Materials Research and Engineering	PUB	Public Utilities Board
CCGT	Combined cycle gas turbine	IMO	International Maritime Organisation	PV	Photovoltaic
CDM	Clean Development Mechanism	IPCC	Intergovernmental Panel on Climate Change	ReCAAP	Regional Cooperation Agreement on Combating Piracy and Armed Robbery Against Ships in Asia
CEPO	Clean Energy Programme Office	ISC	Information Sharing Centre	REVT	Residential Envelope Transmittance Value
CER	Certified Emission Reduction	JRC	Jurong Rock Cavern	RIEC	Research, Innovation and Enterprise Council
CERT	Clean Energy Research and Test-bedding Programme	LNG	Liquefied natural gas	R&D	Research and Development
CNG	Compressed natural gas	LRT	Light Rail Transit	SCEM	Singapore Certified Energy Manager
CO	Carbon monoxide	LTA	Land Transport Authority	SINERGY	Singapore Initiative in New Energy Technologies
CO ₂	Carbon dioxide	MEWR	Ministry of the Environment and Water Resources	SOMS	Straits of Malacca and Singapore
COE	Certificate of Entitlement	MFA	Ministry of Foreign Affairs	SO ₂	Sulphur dioxide
EAS	East Asia Summit	MND	Ministry of National Development	TAGP	Trans-ASEAN Gas Pipeline
EASe	Energy Efficiency Improvement Assistance Scheme	MOF	Ministry of Finance	TIDES	Technology Innovation and Development Scheme
EDB	Economic Development Board	MOT	Ministry of Transport	UN	United Nations
EIA	Energy Information Administration	MRT	Mass Rapid Transit	UNEP	United Nations Environment Programme
EMA	Energy Market Authority	MTI	Ministry of Trade and Industry	UNFCCC	United Nations Framework Convention on Climate Change
EPG	Energy Policy Group	MTOE	Million tonnes of oil equivalent	USEPA	US Environment Protection Agency
ERP	Electronic Road Pricing	MTPA	Million tonnes per annum	VQS	Vehicle Quota System
ESCO	Energy services company	NCCS	National Climate Change Strategy	WMO	World Meteorological Organisation
ESI	Energy Studies Institute	NEA	National Environment Agency		
ESU	Energy Sustainability Unit	NES-SSN	Nuclear Energy Safety Sub Sector Network		
ETTV	Envelope Thermal Transfer Value	NO _x	Oxides of nitrogen		
EVS	Electricity Vending System	NRF	National Research Foundation		
E ² PO	Energy Efficiency Programme Office	NTU	Nanyang Technological University		
E ² SINGAPORE	Energy Efficient Singapore	NUS	National University of Singapore		
GDP	Gross domestic product				
GFA	Gross floor area				
GHG	Greenhouse gas				
GTP	Global Trader Programme				

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A **ukulele** design, Singapore

