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Country Chapter

State of the 3Rs in Asia and the Pacific

The Republic of Singapore

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Disclaimer

This country chapter for Singapore was prepared as an input for the 8th 3R Forum in Asia and the Pacific. Purpose of this country report is to assess the status of 3R implementation in Asia and the Pacific and to share the knowledge of 3R activities among the region.

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This publication is intended to provide expert-based assessment of regional progress of 3R policy implementation in selected countries and regions in Asia and the Pacific, particularly in response to the Hanoi 3R Goals (2013-2023) adopted at the 4th Regional 3R Forum in Asia and the Pacific in Hanoi in March 2013.

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ABBREVIATION

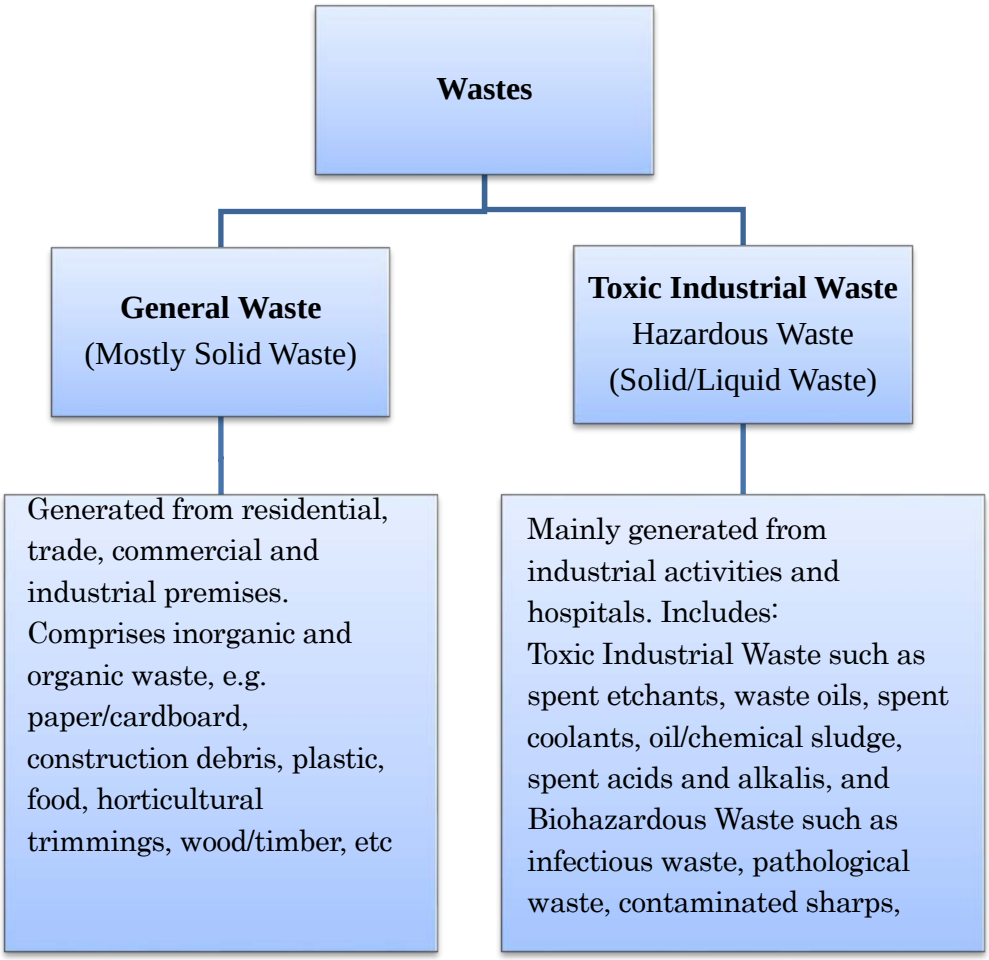
EDB	Economic Development Board
CGNPC	China Guangdong Nuclear Power Holding Corporation
CH_4	Methane
CO_2	Carbon dioxide
EPR	Extended Producer Responsibility
GDP	Gross Domestic Product
Gg	gigagram
GHG	Greenhouse Gas
ICCS	International Coastal Cleanup Singapore
IMCSD	Inter-Ministerial Committee on Sustainable Development
IPCC	Inter-governmental Panel on Climate Change
MEWR	Ministry of the Environment and Water Resources
MPA	Maritime and Port Authority of Singapore
MSW	Municipal Solid Waste
NEA	National Environment Agency
N2O	Nitrous oxide
RC	Residents' Committee
SPA	Singapore Packaging Agreement
SSB	Sustainable Singapore Blueprint
TIW	Toxic industrial wastes

CONTENTS

A: WASTE DEFINITION

Wastes in Singapore can be classified as general waste and toxic industrial waste. General wastes consist mainly of waste from households, trade, commercial and industrial premises. Toxic industrial wastes are hazardous wastes generated from industrial activities. A total of 3.04 million tonnes of general wastes was disposed of in 2014. The bulk of these wastes include paper/cardboard, food, plastic, horticultural trimmings, wood/timber, etc.

The following table shows the waste characterisation.



Source: Data obtained from NEA Website

Figure A-1 Waste Characterisation

B: COUNTRY SITUATION

The Republic of Singapore is a small island state of approximately 718 km^2 and stands at the crossroads of South East Asia. The city state is made up of mainland Singapore and some 60 islets. In 2014, the city state had an estimated population of 5.54 million. At 7,697 per square kilometre, Singapore has one of the highest population densities in the world. The main economic drivers for Singapore are the manufacturing and service industries, including finance, aviation, tourism, petrochemicals, electronics and biotechnologies. Singapore's port and airport facilities are amongst the busiest in the world, making it a major trading centre.

The extensive industrialisation has dictated the need for effective governance in environmental management and pollution prevention. Through policy intervention since the 1960s, Singapore is a well-planned and clean city. Waste management in Singapore is achieved through an efficient system of planning controls, licensing and enforcement.

Singapore's waste management system is motivated by two guiding principles:

a) Maintaining high levels of public health; and
b) Optimising resource utilisation.

In short, the waste collection, disposal and treatment methods must safeguard public health and maximise the value recovered from waste. In Singapore, waste that is not recycled or reused is classified either as incinerable or non-incinerable waste. Incinerable waste is sent to the incineration plants, where the waste is incinerated and turned into an ash residue. The volume of residual ash is just 10% of the volume of the waste. This mitigates the need for landfill space. The incineration process produces heat energy, which is in turn converted to electricity that is fed into the national grid. The residual ash is sent to the Semakau landfill. The non-incinerable waste fraction goes straight to the Semakau landfill after treatment if necessary.

As a small city state, Singapore has to make prudent use of land to house its growing population and support economic growth. Continual building of waste disposal facilities to meet increasing amounts of waste requires land that could be put to better use for industries, housing, water catchments, and transportation, which are important for Singapore's progress. Furthermore, investments in waste disposal facilities are costly and lead to higher waste disposal costs. Recognising the need to reduce waste disposal, the then Ministry of the Environment started to actively promote waste minimisation from 1991. To drive waste minimisation efforts, the National Environment Agency (NEA), a statutory board formed in 2002, adopted waste management strategies based on the 3Rs, that is, Reduce waste at source (or waste avoidance), Reuse waste, and Recycle waste. Such an approach helps to defer the construction of new disposal facilities and hence reduce the demand for land to build these facilities.

An Inter-Ministerial Committee on Sustainable Development (IMCSD) that was set up in January 2008 to develop key strategies for Singapore's sustainable development drew up a Sustainable Singapore Blueprint (SSB) with recommendations for a sustainable Singapore. Among the goals identified in the SSB are targets for Singapore to improve the overall waste recycling rate to 70%

by 2030.

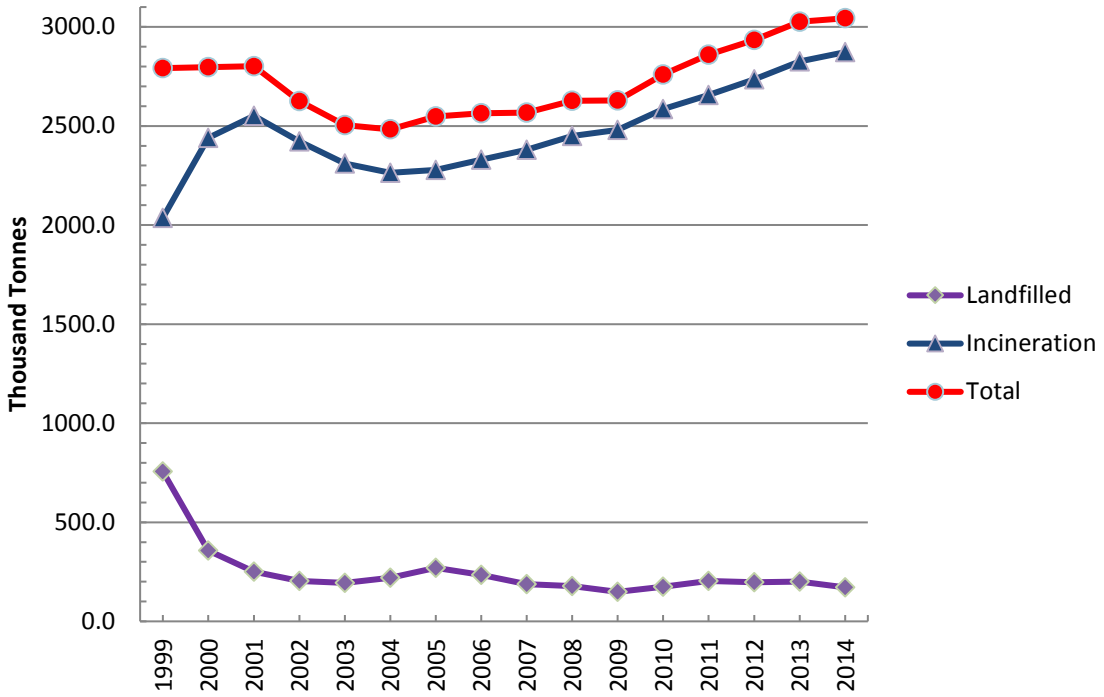
The Ministry of the Environment and Water Resources (MEWR) and the NEA have embarked on a 'Towards Zero Waste' vision under the Sustainable Singapore Blueprint. Resource and land scarce Singapore must find ways to extend the lifespan of its landfills and maximise the use of its resources. A 'Towards Zero Waste' mindset and culture encapsulate these ideas. By building a unifying vision, Singapore hopes to expand awareness of its waste situation significantly and spur "reduce, reuse and recycle" efforts in every sphere *(Source: Ministry of the Environment and Water Resources, Our Waste Situation 2014).*

C: 3R INDICATORS

I. Total MSW Generated and Disposed and MSW Generation per Capita

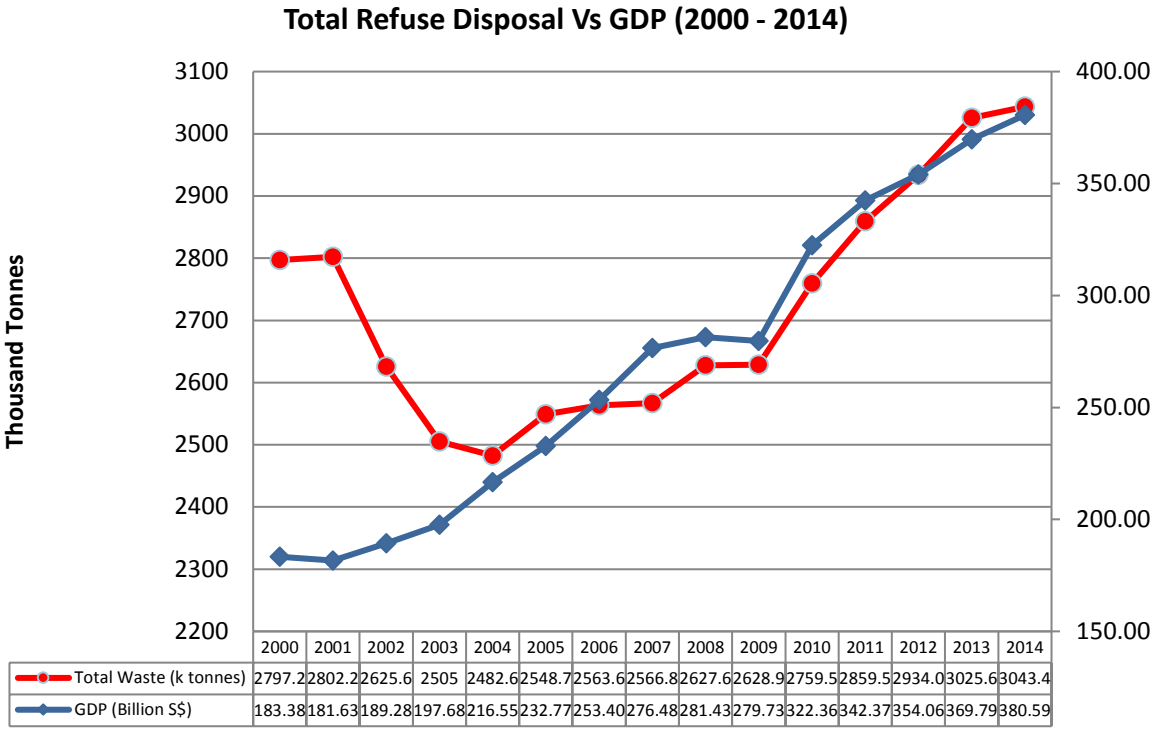
Singapore's growing population, which increased from 2.1 million in 1970 to 5.47 million in 2014, and sustained economic growth have contributed to a 7-fold increase in solid waste disposal quantities from 1,260 tonnes a day in the 1970s to 8,338 tonnes a day in 2014.

The figure below shows the amount of solid waste disposed of at the disposal facilities from 1999 to 2014.



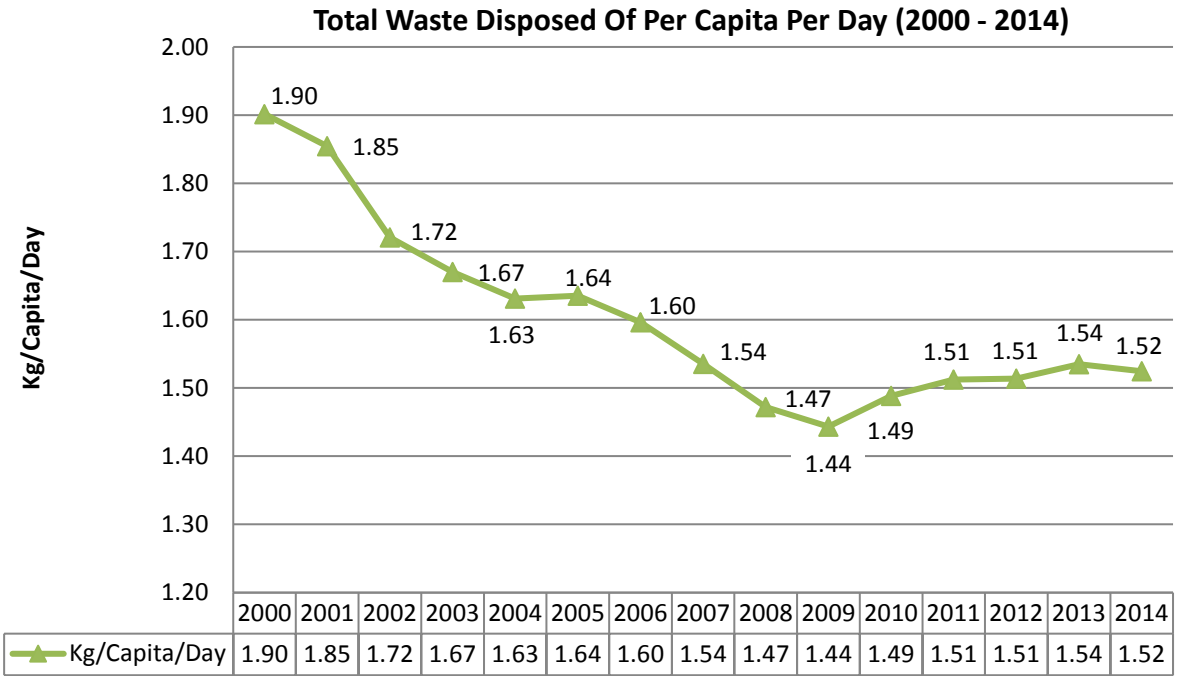
Source: Data obtain from NEA Website, Waste Management, Refuse Disposal Figures

Figure C-1 Disposal of Incinerable vs Non-Incinerable Waste (1999-2014)



Source: Data obtain from NEA Website, Waste Management, Refuse Disposal Figures & Singapore Department of Statistics, GDP

Figure C-2 Total Refuse Disposal Vs GDP (2000-2014)



Source: Data obtained from NEA Website, Waste Management, Refuse Disposal Figures & Singapore Department of Statistics, Population

Figure C-3 Total Waste Disposed Of Per Capita Per Day (2000-2014)

The main sources of incinerable wastes include municipal waste (trade, commercial and residential), wastes generated from factories and industries, construction and various organizations such as hospitals and educational institutions. It is estimated that half of the incinerable wastes disposed of in Singapore come from the industrial and commercial sectors.

Based on 2014 waste statistics, approximately 60% of the total waste generated were recycled, 38% incinerated and 2% landfilled.

Waste Stream	Generated (tonnes)	Recycled (tonnes)	Disposed (tonnes)	Recycling Rate
Construction Debris	1,269,700	1,260,000	9,700	99%
Used Slag	366,300	361,200	5,100	99%
Ferrous Metal	1,445,800	1,388,800	57,000	96%
Scrap Tyres	26,200	23,100	3,100	88%
Non-ferrous Metals	118,400	94,700	23,700	80%
Wood/Timber	367,900	293,500*	74,400	80%
Horticultural Waste	278,300	163,000*	115,300	59%
Paper/Cardboard	1,237,400	646,500	590,900	52%
Glass	79,500	15,700	63,800	20%
Ash & Sludge	148,500	21,700	126,800	15%
Food Waste	788,600	101,400	687,200	13%
Textile/Leather	158,600	16,800	141,800	11%
Plastics	869,000	80,000	789,000	9%
Others (includes stones, ceramics & rubber)	360,300	4,700	355,600	1%
Total	7,514,500	4,471,100	3,043,400	60%

* Includes 201,300 tonnes used as fuel in biomass plants

Source: NEA website, waste statistics and overall recycling, 2014

Figure C-4 Recycling Rate for 2014

II. Overall Recycling Rate and Target (%) and Recycling Rate of Individual Components of MSW

To attain the SSB targets and achieve the long-term "towards zero waste" vision, the NEA engages and works in partnership with various organisations in the people, private and public sectors to plan and implement waste minimisation and recycling programmes.*(Source: NEA, 3R Guidebook for*

Hotels Published on 1 July 2011)

The statistics（**Figure C-5**）show that there is an upward trend in waste recycling from 2007 (54%) to 2014 (60%) and Singapore is on track to achieve the SSB 2030 target of 70%. There was little variation in total waste disposed of per capita (kg/day/person) at 1.51 – 1.54 over the last four years.

GRAB OUR RESEARCH > KEY ENVIRONMENT STATISTICS

SOLID WASTE MANAGEMENT

Solid Waste Management	Unit	2007	2008	2009	2010	2011	2012	2013	2014
Total waste generated[1]	Mil tonnes/yr	5.60	5.97	6.11	6.52	6.90	7.27	7.85	7.51
Total waste recycled[2]	Mil tonnes/yr (%)	3.03 (54%)	3.34 (56%)	3.49 (57%)	3.76 (58%)	4.04 (59%)	4.34 (60%)	4.83 (61%)	4.47 (60%)
Total waste incinerated	Mil tonnes/yr (%)	2.38 (43%)	2.45 (41%)	2.48 (41%)	2.59 (40%)	2.66 (38%)	2.73 (37%)	2.82 (36%)	2.87 (38%)
Total waste landfilled[3]	Mil tonnes/yr (%)	0.19 (3%)	0.18 (3%)	0.15 (2%)	0.17 (2%)	0.20 (3%)	0.20 (3%)	0.20 (3%)	0.17 (2%)
Total domestic waste disposed of	Mil tonnes/yr	1.50	1.48	1.52	1.60	1.64	1.65	1.70	1.74
Total domestic waste disposed of per capita	kg/day/person	0.88	0.84	0.84	0.86	0.87	0.85	0.87	0.87
Domestic recycling rate[2]	%	Not available	Not available	Not available	Not available	Not available	21%	20%	19%
Total non-domestic waste disposed of	Mil tonnes/yr	1.07	1.14	1.11	1.16	1.22	1.28	1.32	1.30
Total non-domestic waste disposed of per $billion GDP[4]	Tonnes a day/GDP ($billion)	Not available	Not available	Not available	Not available	Not available	9.9	9.8	9.4
Non-domestic recycling rate[2]	%	Not available	Not available	Not available	Not available	Not available	75%	77%	76%
Total energy produced from incineration	MWh	974,945	1,048,072	1,064,956	1,173,298	1,206,197	1,250,203	1,263,554	1,260,027
Lifespan of Landfill[5]	years	35-40	35-40	35-45	35-45	35-45	35-45	35-45	36

[1] Total waste generated = Total waste recycled + Total waste incinerated + Total waste landfilled
[2] Singapore's Sustainable Blueprint target for 2030 is 70% for overall recycling rate, 30% for domestic recycling rate and 81% for non-domestic recycling rate.
[3] Total waste landfilled includes non-incinerable waste such as construction and demolition waste, used slag and treated sludge etc. and excludes incineration ash generated from waste disposed through incineration.
[4] The figures were revised with the rebasing of the national accounts by Department of Statistics.
[5] Measured from the start of the lifespan of Semakau Landfill, i.e. 1999.

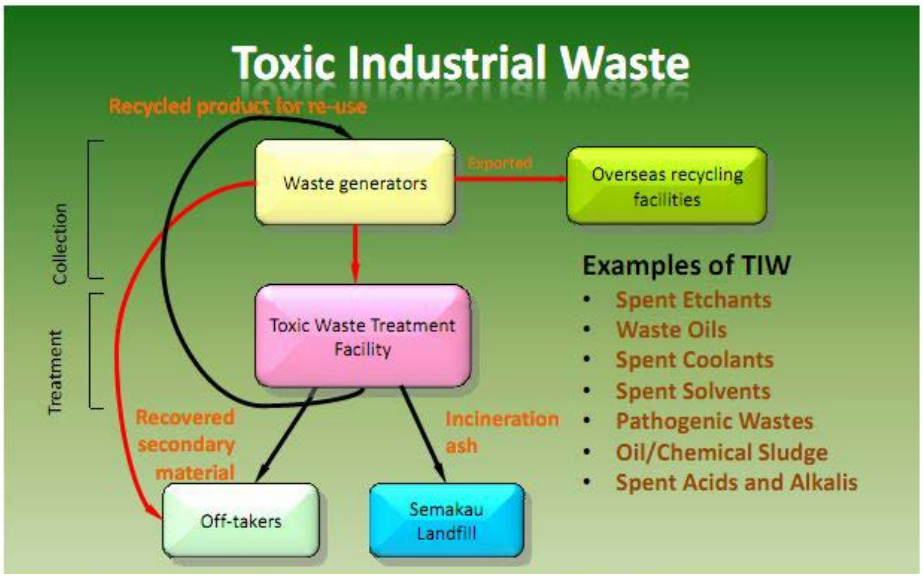
Source: Key Environment Statistics, Ministry of the Environment and Water Resources

Figure C-5 Key Statistics of Solid Waste Management (2007-2014)

Of the 7.51 million tonnes of waste generated in 2014, the majority of construction and demolition wastes, used slag, scrap tyres, ferrous/non-ferrous metals and wood wastes were recycled at rates of between 80-99%. Food waste at 0.79 million tonnes/year and plastic waste at 0.87 million tonnes/year accounted for approximately 10% and 12% of total waste generated respectively. Food and plastic wastes constitute approximately 23% and 26% respectively of the total wastes disposed of at the disposal facilities. The recycling rates of food and plastic wastes at 13% and 9% respectively are relatively low. The low recycling rates of food and plastic wastes for the past ten years show that more efforts are needed to reduce and recycle these wastes.

III. Amount of Hazardous Waste Generated and Disposed in Environmentally Sound Manner

Toxic industrial wastes (TIW) are defined as industrial wastes which may be potentially detrimental to human health and/or the environment and which require special management, treatment and disposal. There are currently more than 2,000 companies in Singapore which handle or use hazardous chemicals. The use of these chemicals generates a wide variety of toxic industrial wastes. The main types of toxic industrial wastes are spent acids, spent solvents, spent etchants, waste oil and other waste sludge. In 2014, approximately 1,136,240 m^3 of TIW were generated. The valuable components of a large amount of TIW generated and collected in Singapore by the licensed collectors are extracted and recovered before the TIW is disposed. Such wastes include spent solvents, spent etchants and waste oils. Those wastes that cannot be recycled or recovered are treated and the residues are disposed of at the Semakau Landfill. The TIW collectors are required to be licensed by NEA and the waste movement is tracked by an e-Tracking System. Currently, there are approximately 200 TIW collectors which are licensed to collect specific types of TIW. Of the 200 collectors, about 10 also operate a wide range of TIW treatment facilities.



Source: NEA, presentation for Asia Pacific Workshop, 2011

Figure C-6 Toxic Industrial Waste Management

IV. Amount of Agricultural Biomass Used

In 2000, about 3.3% of Singapore's land area was classified as forest. There is little productive forestry left on the island, but Singapore continues to have a fairly sizable sawmilling industry, processing timber imported largely from Malaysia and Indonesia. Urbanization and industrialization have taken ever larger amounts of land away from agricultural activity in Singapore. Housing for a growing population and factories stand where rubber and coconut trees used to grow. Nonetheless, agriculture remains part of Singapore's total economic activity. About 3% of the land area is used for farming, primarily for vegetables *(Source: Worldmark Encyclopedia of Nations |2007 |).*

Sembcorp launched a waste-to-energy facility on Jurong Island in 2012 which incinerates wood waste to produce steam for customers on Jurong Island. In early 2014, a unique integrated biomass-solar power generation plant by the China Guangdong Nuclear Power Holding Corporation (CGNPC) was also completed. Also located in the Jurong area, this US$33.6 million hybrid facility is capable of generating up to 9.9-megawatts of electricity by drawing from a unique mix of waste biomass and solar energy. Elsewhere in Singapore, local firm ecoWise runs one of the country's most recognisable biomass projects, the Biomass Co-generation System at the iconic Gardens by the Bay. Horticultural and wood wastes sourced and processed by ecoWise serve as feedstock for the co-generation plant, which can produce up to 0.9 megawatts of electricity and 5.4 megawatts of heat.

However, there is a limited quantity of wood and horticultural wastes from local sources.

Based on the waste statistics 2014 (Figure C-4), approximately 201,300 tonnes of wood/timber and horticulture wastes were used as fuel for biomass power plants. As a highly urbanized city-state, except for small scale vegetable farming, agriculture is not a major sector in Singapore. It is unlikely that wood and horticultural wastes will have a major role in the energy sector.

Singapore has been investing substantially in clean technology capabilities in order to address climate change and reduce reliance on fossil fuel sources. Of interest is the development of its solar energy capabilities, given the country's location in the tropical sunbelt and strong semiconductor manufacturing and innovation base. In Singapore, clean technology (cleantech) was identified as a key economic growth area by the government as early as 2007. Today, the city-state is aiming to develop the sector so that it contributes S$3.4 billion to Singapore's gross domestic product (GDP) and provides 18,000 jobs by 2015 *(Source: Altenative Energy/Clean Technology, EDB, http://www.edb.gov.sg/).*

V. Marine and Coastal Plastic Waste

In Singapore, the Maritime and Port Authority of Singapore (MPA) enforces strict regulations on pollution of the sea from ships within our port waters for ships visiting Singapore. MPA also monitors the ships in port to ensure compliance to the regulations. Under Singapore's Prevention of Pollution of the Sea Act, it is an offence for any person to throw or deposit into Singapore waters any refuse, garbage, plastics or waste matter. If convicted, offenders are liable to be fined up to a maximum of S$10,000 or imprisoned for up to 2 years or both.

Marine plastic waste in Singapore waters and along Singapore's coastline could be from inland sources or brought in from elsewhere by tides.

The MPA employs a contractor to collect garbage from ships to ensure proper disposal and flotsam retrieval. This ensures that waters are clean and safe for navigation. Garbage collection and flotsam retrieval operations are conducted on a daily basis by a fleet of nine craft (four for garbage collection, 5 for flotsam retrieval). In 2015, a total of 4257.89 tonnes of flotsam and garbage waste was collected.

In 2013, the non-profit organization International Coastal Cleanup Singapore (ICCS) conducted annual beach and mangrove cleanups and published the data on marine trash in Singapore. For the ICCS 2013 study alone, 3,473 volunteers covered 19,476 meters of coastline and collected 14,448 kg (153,147 pieces) of marine trash. The average weight of marine trash collected by each volunteer increased by 32% from 3.1 kg/person in 2002 to 4.2 kg/person in 2013. The average weight of marine trash collected for each meter of coastline increased by 194% from 0.25 kg/m in 2002 to 0.74 kg/m in 2013 *(Insights on Marine Trash in Singapore, August 12, 2014 by Eugene Tay, data from ICCS).*

The top 10 marine trash items collected in 2013 are shown in the following figure:

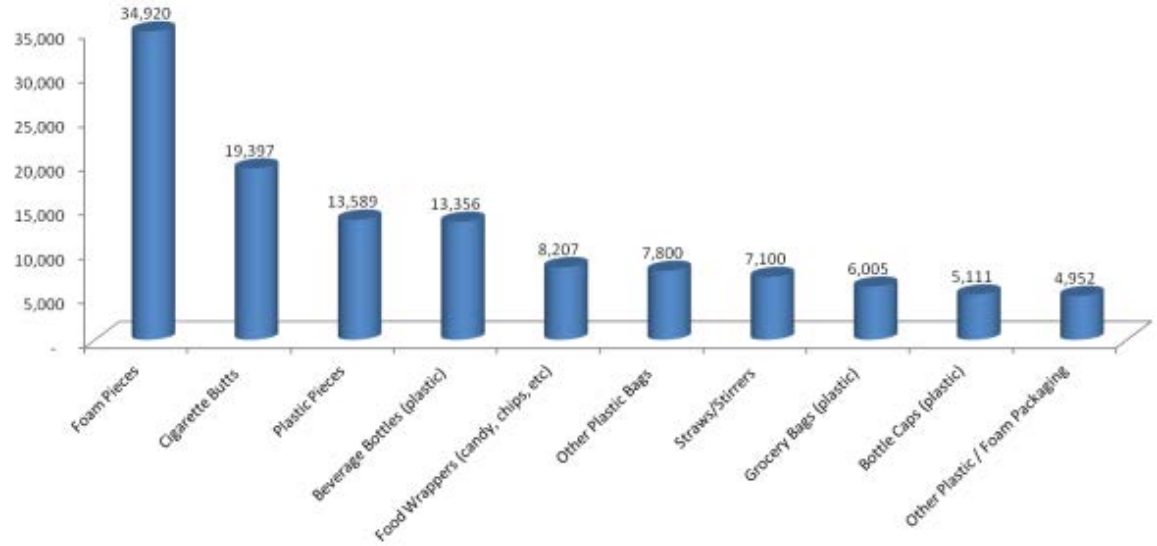
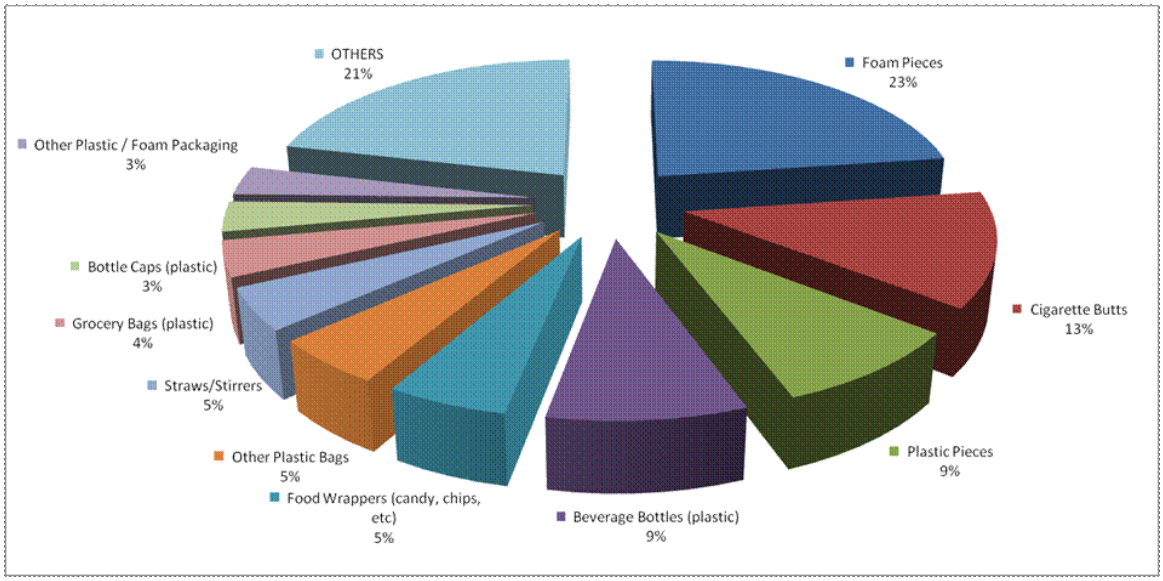


Figure C-7 Top 10 Marine Trash



(Source: International Coastal Cleanup Singapore, ICCS)

Figure C-8 Types of Marine Trash Retrieved

The data shows that almost all the waste, other than cigarette butts, are related to plastic products.

VI. E-Waste Management

In 1996, Singapore acceded to the Basel Convention on the control of export, import and transit of hazardous wastes which may include e-waste. Although its transboundary movement is restricted, e-waste generated by households (such as used televisions, refrigerators, washing machines, hand phones, computers, printers, batteries, electronic items, etc.) in Singapore is not regulated as toxic industrial waste. There is currently no formal regulatory framework dealing with the management of e-waste in Singapore. Reportedly, Singapore has an active second-hand market and effective recycling initiatives, resulting in minimal e-waste ending up in its disposal facilities. Valuable electronic scrap generated by industries are normally sold to local e-waste recycling facilities where precious metals such as gold and platinum are extracted, and recovered materials such as plastics are sent to local recycling companies (*Source: E-waste disposal challenge 'not serious' in Singapore, By Jamie Yap, April 3, 2013).*

The statistical data (2014) published by NEA (Figure C-4) show that the amount of e-waste generated is not significant. The amount of e-waste grouped under other wastes (together with ceramics, silt, etc.) generated was 0.36 million tonnes/year and accounted for about 4.8% of total waste streams of 7.51 million tonnes. NEA estimates that about 60,000 tonnes of electronic waste (e-waste) are generated annually in Singapore, of which about 50 per cent are common household IT products and home appliances while the rest are ICT equipment generated from the commercial and industrial sectors *(NEA, 12 November 2014, News Releases, Electronic Waste Management Made Easier with Implementation of National Standard, http://www.nea.gov.sg).*

As there is no formal system of e-waste collection and recycling, there is no robust data on recycling rates of e-waste available. It is assumed that the large second-hand market and informal recycling sector handles most of the post-consumer e-waste in Singapore. Current e-waste recycling efforts are voluntary initiatives launched by the private companies with the support of the government agencies. One example is the joint effort by telecommunications company StarHub, e-waste recycler TES-AMM and courier firm DHL that encourages consumers to dispose unwanted cellphones, laptops and other electronics in collection bins (called RENEW bins) at various location in Singapore. There are currently 235 RENEW bins at 180 locations around Singapore. (NEA's website on e-waste recycling, *http://www.nea.gov.sg/energy-waste/3rs/e-waste-lamp-battery-recycling/e-waste-recycling*)

Another programme is a six-month trial initiated by Panasonic Asia-Pacific in partnership with South East Community Development Council, the National Environmental Agency (NEA), Best Denki, Cimelia and SembWaste. The programme's recycling and participation rates will be evaluated to determine the feasibility of extending it nationwide. The recycling initiative, called the Heartland E-Waste Recycling Programme pilot, will try to reduce the quantity of heavy metals that will go into the landfill, said the Director-General of the Environmental Protection Division at the National Environment Agency (NEA). The mayor of South East District, said consumer e-waste is less frequently recycled due to the lack of convenient collection options. The pilot will feature a wide range of collection points, including 10 Residents' Committee (RC) centres, five schools and the Best Denki, retail outlet at Parkway Parade. The RC centres will also collect general recyclables such as paper and plastic bottles. The Town Council will be providing removal services for bulky items such as refrigerators to housing board residents in the district, while Best Denki will collect bulky e-waste islandwide for a fee upon the purchase and delivery of new appliances. E-waste collected under the programme will be sent to a recycler, Cimelia, to be segregated and for essential raw materials, such as plastics and precious metals, to be retrieved. The general recyclables are then sent to SembWaste, a private waste management company, for regular recycling *(News released by Panasonic Asia Pacific, July 2013).*

In November 2014, a national standard on the management of end-of-life technology in ICT equipment, Singapore Standard SS587:2013, was jointly announced by the National Environment Agency (NEA) and the Singapore Standards Council at the Electronics Recycling Asia Conference 2014. The establishment of the standard aims to promote the adoption of best practices by businesses and industries in managing their electronic waste, and raise awareness among businesses and industries on environmentally responsible electronic waste management. To encourage the adoption of SS587, SPRING Singapore is offering co-funding assistance for small and medium enterprises (SMEs) through the Capability Development Grant, which supports up to 70 per cent of the qualifying costs for the standard adoption. NEA also recognises the achievements of organisations that have been successfully certified to the standard. A dedicated portal on NEA's website provides information and resources on SS587 and how to attain the certification *(Source: News Releases, Electronic Waste Management Made Easier with Implementation of National Standard http://www.nea.gov.sg/corporate-functions/newsroom/news-releases/electronic-waste-management-made-easier-with-implemention-of-national-standard).*

In November 2015, the National Environment Agency called for a tender to conduct a study on the collection, recycling and management of e-waste.
http://www.nea.gov.sg/corporate-functions/newsroom/advisories/nea-to-conduct-study-on-collection-recycling-and-management-of-e-waste

VII. Principle of Extended Producer Responsibility (EPR)-Singapore Packaging Agreement

At present, Singapore does not have legislation on EPR. Nonetheless, Singapore has been exploring new avenues such as establishing 3P (People, Private and Public) partnerships to achieve its ambitious environmental goals.

Singapore packaging agreement

In 2007, NEA signed a voluntary agreement, the Singapore Packaging Agreement (SPA), with industry and other parties to reduce packaging waste, which constitutes about one-third by weight of Singapore's domestic waste. The Agreement aims at creating an opportunity for the industry to assume greater corporate responsibility to reduce their packaging waste and enjoy cost savings through process and product improvements. At the same time, it offers a platform where companies can share their experiences, exchange practical ideas and collaborate to develop cost-effective solutions to reduce waste. 177 organisations, including industry associations, companies, and NGOs, have signed this Agreement to date.

From 2007 to 2016, the signatories have cumulatively reduced about 32,000 tonnes of packaging waste, resulting in cumulative savings of more than S$75 million in the material costs of locally consumed products. Every year, the 3R Packaging Awards are presented to deserving SPA signatories for their notable efforts and successful packaging waste reduction initiatives, such as reduction of the thickness, weight or size of packaging, optimisation of production processes, elimination of unnecessary packaging and changing the way of product package[1].

On 22 October 2015, a packaging benchmarking database was launched to enable businesses to discover the potential for improving their packaging design and use of materials, and spur them to take action to reduce the amount of packaging in their products. This will ultimately help conserve resources and reduce waste generation. To date, the database displays the packaging weight benchmarks for sixteen product categories.

[1] More details on the SPA, as well as the work done by the award winners in reducing waste may be found at NEA's website, *http://www.nea.gov.sg/SPA*.

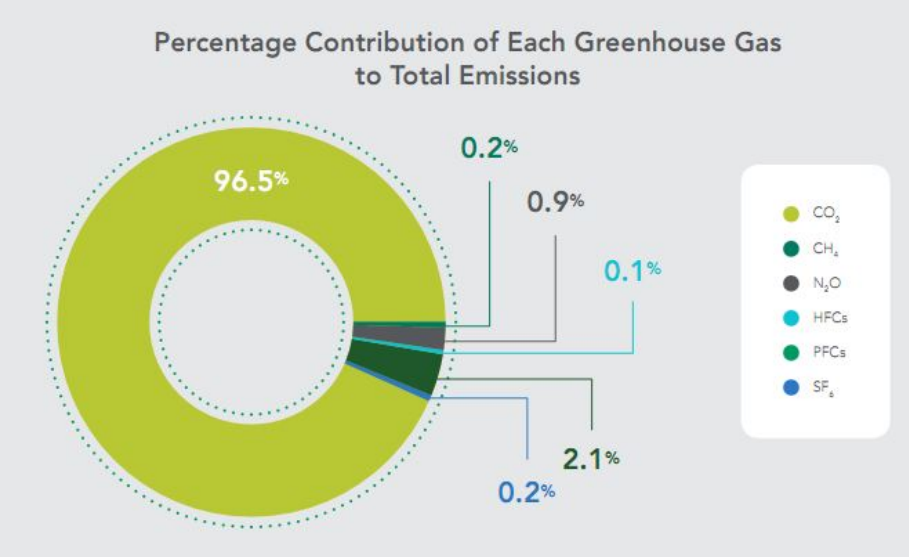
VIII. Greenhouse Gas (GHG) Emissions from Waste Sector

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

Singapore's emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) were estimated using the Revised 1996 Inter-governmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, in line with the user manual for the guidelines on national communications from non-Annex I Parties.

Singapore's greenhouse gas emissions for 2010 totalled 46,831.68 gigagram (Gg) CO_2-equivalent.

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



Source: SINGAPORE'S THIRD NATIONAL COMMUNICATION AND FIRST BIENNIAL UPDATE REPORT, Under the United Nations Framework Convention on Climate Change, December 2014, PUBLISHED BY National Environment Agency

Figure C-9 Percentage Contribution of Each Greenhouse Gas to Total Emissions

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

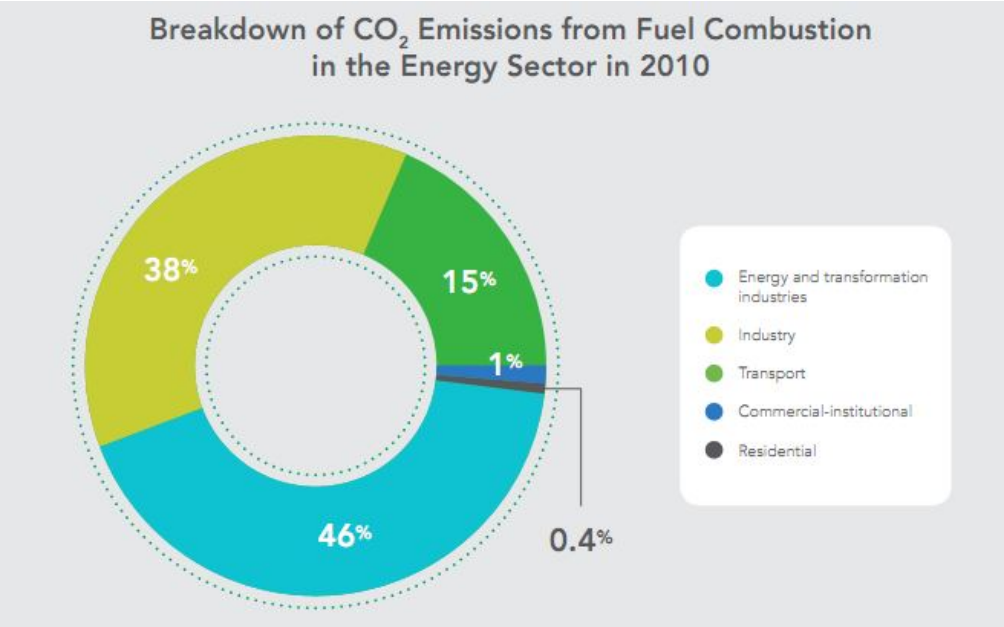
Greenhouse Gas Source and Sink Categories[17]	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
Total (Net) National Emissions (Gg CO_2-equivalent per year)	45,202.88	113.91	400.79	39.94	987.91	86.25
All Energy	45,202.88	42.70	304.99			
Fuel combustion	45,047.04	42.70	304.99			
Energy and transformation industries	20,790.82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

Source: SINGAPORE'S THIRD NATIONAL COMMUNICATION AND FIRST BIENNIAL UPDATE REPORT, Under the United Nations Framework Convention on Climate Change, December 2014, PUBLISHED BY National Environment Agency

Figure C-10 Breakdown of the Total Greenhouse Gas Emissions 2010

1. Breakdown of emissions in the energy section

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



Source: SINGAPORE'S THIRD NATIONAL COMMUNICATION AND FIRST BIENNIAL UPDATE REPORT, Under the United Nations Framework Convention on Climate Change, December 2014, PUBLISHED BY National Environment Agency

Figure C-11 Breakdown of CO_2 Emissions from Fuel Combustion in the Energy Sector 2010

As heat from the incineration of waste is recovered to produce electricity in Singapore, CO_2 and N2O emissions from **waste incineration are reported in the energy sector**. According to the IPCC Guidelines, CO_2 emissions from waste incineration are estimated from the portion of the waste that is fossil fuel based and the biomass fraction is excluded. **Waste incineration was estimated to contribute 1,183.86Gg** of CO_2 to the total greenhouse gas emissions in 2010.

2. Measures to reduce emissions

The Singapore Government will continue to raise awareness and build capabilities to improve energy efficiency across the sectors. A major part of this effort involves addressing sector-specific barriers using incentives or regulatory measures where appropriate. In order to reduce emissions, the Singapore government has undertaken several measures as described as follows:

- Shifting to Cleaner Energy Sources
- Improving Industrial Energy Efficiency
- Greening Buildings
- Shifting Travel Demand to Low-Emission modes and Reducing vehicular Emissions
- Improving Energy Performance Standards of Household Appliances and Promoting Energy Efficiency to Households
- Reducing Emissions from Waste and Wastewater Treatment

3. Reducing emissions from waste sector

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

The government projects the mitigation measures in the solid waste and used water sector to achieve 0.15MT of CO_2 eq abatement by 2020, with an estimated 0.06MT of CO_2-eq in 2012.

Source: SINGAPORE'S THIRD NATIONAL COMMUNICATION AND FIRST BIENNIAL UPDATE REPORT, Under the United Nations Framework Convention on Climate Change, December 2014, PUBLISHED BY National Environment Agency

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With limited land resources available for waste disposal, the National Environment Agency (NEA) has adopted the following strategies to manage the growth in solid waste generation:

- Minimise and segregate waste at source;
- Develop cost-effective collection, recycling and disposal systems;
- Build a resource-efficient society; and
- Maximise energy and resource recovery as well as landfill lifespan

Today, Singapore has in place an integrated solid waste management system. Waste that is not reused or segregated at source for recycling, is collected and sent to disposal facilities. All incinerable waste is disposed of safely at waste-to-energy plants, while non-incinerable waste and ash residues from the incineration process are disposed of at the offshore Semakau Landfill.

Singapore's overall recycling rate has increased from 40% in 2000 to 60% in 2014. There is an overall waste recycling rate target of 70% by 2030, as prescribed under the Sustainable Singapore Blueprint. Singapore has achieved this through a combination of initiatives, including voluntary partnerships, continued education and outreach on the 3Rs, funding schemes, industry development and legislation. With more waste minimisation and recycling, less resources need to be set aside to build disposal facilities, including freeing up land which can be used for other purposes.

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