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This report is based on a targeted review of Singapore’s approach to climate change, focusing on how the country drives energy efficiency and reduces GHG emissions in the ICT sector, particularly in data centers. It aims to reflect the various measures undertaken by the Singapore Government, present lessons learned, key takeaways and challenges that continue to lie ahead. The information in this version is current as of end November 2023.

The purpose of this report is to provide the key lessons for broad, multistakeholder consideration and dialogue for what countries could consider as they approach “greening” the ICT sector. It is important to note that addressing all the issues raised in this report does not guarantee a perfect, or even workable, enabling environment to meet the global climate change challenge. This is because the effectiveness of these measures can be affected by exogenous factors and the unique national circumstances of each country.
## ABBREVIATIONS

<table>
<thead>
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
</tr>
<tr>
<td>CCP</td>
<td>Career Conversion Program for Sustainability Professionals</td>
</tr>
<tr>
<td>COP</td>
<td>Conference of the Parties</td>
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<tr>
<td>CDP</td>
<td>Carbon Disclosure Project</td>
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<tr>
<td>DC</td>
<td>Data Center</td>
</tr>
<tr>
<td>DC-CFA</td>
<td>Data Center-Call for Application</td>
</tr>
<tr>
<td>ECA</td>
<td>Energy Conservation Act</td>
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<tr>
<td>EDB</td>
<td>Economic Development Board of the Government of Singapore</td>
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<tr>
<td>EMA</td>
<td>Energy Market Authority</td>
</tr>
<tr>
<td>E2F</td>
<td>Energy Efficiency Fund</td>
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<tr>
<td>ESG</td>
<td>Environmental, Social and Governance</td>
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<tr>
<td>ESP</td>
<td>Enterprise Sustainable Program</td>
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<tr>
<td>GEF</td>
<td>Grid Emission Factor (GEF)</td>
</tr>
<tr>
<td>GeSI</td>
<td>Global Enabling Sustainability Initiative</td>
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<tr>
<td>GHG</td>
<td>Greenhouse gases</td>
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<tr>
<td>GMDC</td>
<td>Green Mark for Data Centers</td>
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<tr>
<td>GSMA</td>
<td>Groupe Speciale Mobile Association</td>
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<tr>
<td>ICT</td>
<td>Information, Communication and Technology</td>
</tr>
<tr>
<td>IoT</td>
<td>Internet-of-Things</td>
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<tr>
<td>IMCCC</td>
<td>Inter-Ministerial Committee on Climate Change</td>
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<tr>
<td>IMDA</td>
<td>InfoComm Media Development Authority</td>
</tr>
<tr>
<td>Infocomm</td>
<td>Information and Communication</td>
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<tr>
<td>ITU</td>
<td>UN International Telecommunication Union</td>
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<tr>
<td>LEDS</td>
<td>Long-Term Low-Emissions Development Strategy</td>
</tr>
<tr>
<td>M1</td>
<td>M1 Limited (formerly Mobile One)</td>
</tr>
<tr>
<td>MSME</td>
<td>Micro, Small and Medium Enterprises</td>
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<tr>
<td>MtCO2e</td>
<td>Million tons of carbon dioxide equivalent</td>
</tr>
<tr>
<td>NCCS</td>
<td>National Climate Change Secretariat</td>
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<tr>
<td>NEA</td>
<td>National Environment Agency</td>
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<td>PUE</td>
<td>Power Usage Effectiveness</td>
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<td>SS564</td>
<td>Singapore Standard for Green Data Centers</td>
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<td>SBTi</td>
<td>Science Based Target Initiative</td>
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<tr>
<td>SingTel</td>
<td>Singapore Telecommunications Ltd</td>
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<tr>
<td>StarHub</td>
<td>StarHub Limited</td>
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<tr>
<td>SDGs</td>
<td>UN Sustainable Development Goals</td>
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<tr>
<td>SG</td>
<td>Singapore</td>
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<tr>
<td>SGX</td>
<td>Singapore Exchange</td>
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<tr>
<td>TCFD</td>
<td>Task Force on Climate-Related Financial Disclosure</td>
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<td>TDC</td>
<td>Tropical Data Centre Standard</td>
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<tr>
<td>Telcos</td>
<td>Telecommunications operators</td>
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<td>UN</td>
<td>United Nations</td>
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EXECUTIVE SUMMARY

Climate change presents a global challenge that necessitates collaborative efforts from all nations. Failing to take concrete steps to curb greenhouse gas (GHG) emissions can lead to severe consequences linked to climate change. Countries that proactively prepare are better equipped to respond. Both international collaboration and adoption of effective domestic measures for emissions mitigation and climate adaptation are key to minimizing the negative impacts of climate change now and for the generations ahead.

The use of sensors, digital twins, machine-learning, and other digital tools and applications can boost productivity and energy management, benefiting nearly all sectors, including government, health, education, manufacturing, transportation, and agriculture. Digital technologies have the potential to help other industries save 20 percent of global carbon emissions. However, these digital tools and applications consume energy, and they contribute to GHG emissions. It has been estimated that their carbon footprint may account for about 14 percent of the world’s carbon emissions by 2040. As a result, “greening” the information and communication technology (ICT) infrastructure is crucial.

Despite its relatively small contribution of 0.1 percent to global emissions, Singapore faces significant challenges due to its lack of renewable energy sources and vulnerability to climate change. Additionally, the country serves as a data center (DC) hub, accounting for more than 60 percent of the DC market in Southeast Asia. DCs in the ICT infrastructure are notably energy-intensive and pose a substantial challenge to climate mitigation efforts. The Government of Singapore (the Government) is taking proactive steps to address these issues and build a more sustainable and resilient future. The country targets reduction of emissions by 2030 to 60 MtCO2e and is committed to achieving net zero emissions by 2050.

No “one-size-fits-all” approach exists for addressing climate change. Each country must tailor its solutions to fit its specific circumstances and priorities. No one country can tackle this challenge alone—it is a shared global endeavor. Therefore, it is essential to learn from the experiences of different nations. Singapore’s approach to managing energy consumption and GHG emissions in the ICT sector, particularly in DCs, serves as a valuable case study for other countries.

This report seeks to outline Singapore’s journey and key initiatives undertaken to tackle the climate issue and reduce GHG emissions. The aim is to derive insights and key lessons for policymakers in other countries with similar constraints. The following key takeaways have emerged from our analysis and findings in this report.

• **Adopt a “whole-of-nation” approach.** Climate change is an issue with many dimensions that cut across the responsibilities of different ministries and agencies. Recognizing this, Singapore adopted a whole-of-government approach in the Singapore Green Plan 2030. The Government has taken this further as a “whole-of-nation” effort, partnering businesses, citizens, civil society, and key stakeholders to achieve the Green Plan, fostering a shared vision and collective responsibility.

• **Balance sustainability and economic considerations.** Recognizing the importance of DCs for the digital economy, Singapore has taken a proactive approach to intervene early to manage DC growth sustainably and

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in line with national climate change commitments. To prioritize energy efficiency, Singapore imposed a three-year pause to new DCs, highlighting the need for balancing sustainability and economic considerations.

- **Implement timely legislative and policy measures.** Governments play a crucial role in driving system change, including the implementation of regulations and policies. Singapore was quick to introduce the Energy Conservation Act (ECA) in 2013, establishing a legislative framework for industrial energy efficiency, mandating energy efficiency requirements and energy management practices. It became the first country in Southeast Asia to introduce a carbon tax in January 2019.

- **Implement standards, certifications, and best practices.** Governments can drive systemic change and shape behavior by setting industry standards, certifications, and best practices to promote energy efficiency. Singapore has introduced the Green Data Center Standard SS564, the Green Mark Data Center (GMDC) certification, a tropical DC standard for optimizing energy efficiency, and stringent efficiency criteria for new DCs.

- **Emissions reporting and targets.** Governments play a pivotal role in spearheading and enhancing the disclosure of sustainability information, ensuring that companies can uphold the same level of rigor and data quality when tracking and reporting their sustainability performance.

- **Government to take the lead.** When the public sector takes the lead in embracing sustainable practices, it can accelerate progress towards national sustainability goals and inspire others to follow. By setting their own goals to peak GHG emissions around 2025 and achieve net-zero emissions around 2045, five years ahead of the national zero emissions by 2050, the public sector in Singapore has demonstrated the importance for every public agency to take the lead and be exemplary.

- **Partner with industry.** Partnering with industry through consultation and collaboration is a crucial step that governments should take when implementing regulations and initiatives to ensure a smooth transition and minimize risks. Governments, businesses, civil society, and communities must work together. Collaborations with industry can also lead to innovative solutions through co-creation and implementations that are practical, effective, and well-received.

- **Support companies to improve energy efficiency.** Companies can face significant challenges in implementing energy efficiency projects, including high upfront capital costs and infrastructural constraints. The Singapore Energy Efficient Fund provides financial support for companies to adopt energy-efficient technologies, install energy management information systems, conduct energy assessments, and improve resource efficiency in facility design.

- **Build industry capabilities through “green” skills training.** Countries need to build local capacities in sustainability and integrate them into their climate change strategies. Transitioning to a greener economy requires more workers skilled in green and sustainable practices. Singapore established programs to train and certify qualified professionals, including an Energy Efficiency Technology Centre that helps companies and SMEs implement energy efficiency initiatives. A national Green Skills training program is being developed, starting with roles and skills needed to support the energy sector and sustainability reporting.

As the digital economy booms in less developed countries and the amount of data being created escalates, there will be increasing demand for ICT infrastructure, data centers, and energy. It is crucial for these countries to prioritize and manage energy efficiency and GHG emissions early. For countries that have limited resources and capacity, a progressive and scale-up approach is recommended. Countries could consider prioritizing climate mitigation and adaptation as a national agenda, supported by legislations and regulatory policies, adopting a whole-of-government approach with an inter-ministerial governance structure, implementing international sustainability standards, and allocating public spending.

Addressing climate change is a pressing global imperative that requires collaborative efforts worldwide. The report concludes by examining key challenges that lie ahead, including (i) Scope 3 emissions reporting; (ii) energy efficiency in legacy data centers; (iii) impacts of increasing demand for digital technology, and (iv) hurdles associated with adoption of sustainable energy sources.
INTRODUCTION AND CONTEXT

The 2015 Paris Agreement represents a common effort by nations to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, through reducing greenhouse gas (GHG) emissions and adapting to climate change. The objectives of climate change mitigation and adaptation are also essential to achieve the UN Sustainable Development Goals (SDGs). 3

Climate action is the imperative of this decade, urgently needed to mitigate negative climate change effects and ensure a sustainable future for all. It requires collective efforts, strong political will, and innovative solutions to achieve low-carbon and climate-resilient societies. As a global challenge, climate change necessitates collaborative efforts by all nations. Without proactive measures to mitigate GHG emissions, the consequences of climate change can be severe. Countries that plan ahead will be better able to respond, both in terms of domestic measures to protect their immediate environment and reduce emissions, and in collaborating internationally to craft effective climate mitigation and adaptation approaches and solutions.

The ICT sector: a catalyst for carbon reduction amidst its own emissions challenge

Digital technologies deployed in the ICT sector can help optimize operations in real-time, leading to improved efficiency, reduced energy use, increased productivity, and more effective resource allocation. Studies found that digital technologies have the potential to help other industries save 20 percent of global carbon emissions by 2030. 4

However, about 1.8 to 4 percent of global emissions currently stem from digital infrastructure and applications. 5 Its carbon footprint could account for as much as 14 percent of the world’s carbon emissions by 2040. 6 Due to accelerated digitalization and the rising use of technologies like Artificial Intelligence (AI), Internet-of-Things (IoT), Cloud Computing, and “Big Data”, it is essential for countries to prioritize emissions reduction for their rapidly expanding ICT infrastructure and services. As a result, greening ICT infrastructure is deemed crucial.

A World Bank study reported that in order for the ICT sector to contribute proportionally to the reduction of global warming, GHG emissions along its value chain must be reduced by half by 2030. 7 The emissions from the digital value chain come from the use of energy and resources to build (embodied emissions), power (operational emissions), and dispose (end-of-life emissions) of digital infrastructure, equipment, and devices. These emissions can be reduced by using more energy-efficient infrastructure, intelligent process controls, and renewable energies. If its carbon footprint is kept in check, digital technology has the potential to deliver emissions savings of as much as seven times the growth in its own carbon footprint between 2019 and 2030. 8

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3 Particularly SDG 13 (climate action), SDG 7 (clean energy), SDG 11 (sustainable cities), SDG 9 (sustainable industry) and SDG 12 (responsible consumption and production).
Singapore’s climate change challenges and opportunities

As a thriving digital technology and innovation hub, Singapore leads Southeast Asia as a data center hub, accounting for more than 60 percent of the region’s DC market.\(^9\) Data centers in the ICT infrastructure are particularly energy-intensive. Singapore supplies around 7 percent of its total energy to DCs and is projected to consume as much as 12 percent of the country’s total energy demand by 2030.\(^10\) If unabated, this growth may pose a challenge to its energy infrastructure.

Despite its relatively small contribution of 0.1 percent to global emissions, Singapore has been proactive in addressing climate change and it is committed to playing its part in GHG reduction. While Singapore faces significant challenges due to its lack of renewable energies and vulnerability to climate change, the Government is taking proactive steps to address these issues and build a more sustainable and resilient future. As part of its Long-Term Low-Emissions Development Strategy (LEDS), the Government has committed to reducing emissions to around 60 MtCO2e in 2030 and achieving net zero emissions by 2050.\(^11\)

Singapore’s ICT “greening” strategies

Recognizing the importance of mitigating GHG emissions, Singapore has implemented various strategies. One key strategy is improving energy efficiency by promoting energy-efficient practices and technologies. Mitigation refers to actions taken to reduce GHG emissions and combat climate change. This case study report focuses on examining Singapore’s mitigation efforts in the ICT sector to address climate change.

Through this case study, we seek to understand Singapore’s approach and how the country introduced policies, programs and initiatives to drive energy efficiency and reduce ICT sector GHG emissions, particularly for data centers. The report seeks to:

(i) Summarize Singapore’s journey and overall approach to addressing climate change by looking at its institutional setup, regulations and policies, and key sustainability programs to drive energy efficiencies.

(ii) Provide an update on the country’s ICT sector GHG emissions and energy consumption.

(iii) Outline the Government’s measures to mitigate the environmental impact of energy-intensive data centers.

(iv) Present key takeaways and future challenges from our research.

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\(^10\) Digital Realty. The future of data centres in the face of climate change. Eco-business.
CHAPTER 1.
Singapore’s Approach to Climate Change

Singapore ranks 35th in the world and 4th in Asia-Pacific, after Tokyo, Seoul, and Sydney in the Sustainable Cities Index 2022. Additionally, it holds the 4th position in the World Economic Forum’s (WEF) Global Competitiveness Report 2022’s Global Competitiveness Index. This underscores the significance of Singapore’s sustainability initiatives while maintaining its continued competitiveness.

Singapore is a country known for its forward-thinking approach to responding to both domestic challenges, such as safeguarding its immediate environment and reducing emissions, and international collaboration in the pursuit of effective solutions. This section of the report aims to highlight some key aspects of Singapore’s overall approach and key initiatives as the country transitions to a sustainable and low-carbon future.

Sustainability has been a long-standing priority of Singapore

Climate change presents an asymmetrical challenge for small island-states like Singapore. Its contribution to global emissions is relatively small, but the impact of climate change on the country can be disproportionately large. As a small, low-lying, and highly urbanized city-state, Singapore is particularly vulnerable to negative climate effects. Geographical constraints—factors such as low wind speeds, flat land, and a lack of geothermal resources—limit the country’s access to alternative clean energy, such as geothermal, wind, and tidal power.12 Despite these challenges, sustainable development has been a longstanding priority for Singapore, even before climate change became a critical global concern. The country has sought to balance economic growth with environmental protection in a mutually reinforcing manner, rather than at the expense of one another.

Singapore has implemented several sustainability initiatives. It has designated large nature reserves, with approximately one-third of the island covered by trees, earning it the nickname “Garden City.” It is also one of the few countries that has frozen vehicle growth, reducing carbon emissions from transportation. It is also a leader in water-usage by “closing the water loop” to reuse every drop of water repeatedly.

Singapore does not subsidize the use of fossil fuel and was the first in Southeast Asia to introduce a price on carbon, covering about 80 percent of emissions. Since the early 2000s, it has transitioned to natural gas, one of the cleanest forms of fossil fuel for power generation. In 2020, about 95.8 percent of its electricity is generated using natural gas.13

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Singapore is also committed to progressively transitioning to greener energy sources, including importing up to 100MW of hydropower from Laos through Thailand and Malaysia. The country aims to import up to 4 gigawatts of low-carbon electricity by 2035, which would make up around 30 percent of its projected electricity supply.

**Singapore’s Green Plan 2030**

Although contributing only 0.1 percent of global emissions, Singapore is committed to playing its part in mitigating climate change. As a tropical small island developing state, it recognizes its vulnerability to extreme weather patterns and rising sea levels. The country is firmly committed to tackling climate issues through decoupling its economic growth from GHG emissions.

Over the years, the Government has introduced various climate change plans, including the Climate Change Strategy (2012), Sustainable Singapore Blueprint (2015), Singapore’s Climate Action Plan (2016), and Charting Singapore’s Low-Carbon and Climate Resilient Future (2020). The Singapore Green Plan 2030 (Green Plan), launched in early 2021, sets out a comprehensive and long-term sustainability roadmap. It outlines the country’s strategies, initiatives, and targets for sustainable development. This initiative is spearheaded by five ministries, focusing on five key pillars: City in Nature, Sustainable Living, Energy Reset, Green Economy, and Resilient Future (Figure 1.1).

The Green Plan 2030 was launched as part of the Singapore’s commitment to fight climate change in alignment with the United Nations’ 2030 Agenda for Sustainable Development. As part of its Long-Term Low-Emissions Development Strategy (LEDS), the country aims to reduce its emissions to around 60 MtCO2e by 2030 and to achieve net zero emissions by 2050. This commitment is in line with the Glasgow Climate Pact adopted at the 26th session of the Conference of the Parties (COP-26) in 2021. The Green Plan represents Singapore’s pledge to take climate action and promote sustainable development, aligned with the global sustainability agenda. It is a “living plan” that evolves over time and will consider technological developments and incorporate the views and aspirations of the people. The Government partners with businesses, civil society, communities, and individuals to ensure successful implementation of the Green Plan.

In line with the Green Plan, Singapore is also implementing sector-specific initiatives. For example:

- In the maritime industry, the Maritime Singapore Decarbonization Blueprint and the Maritime Singapore Green Initiative (MSGI) focus on decarbonization of ports and shipping.

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21 The Ministries of Sustainability and the Environment (MSE), Trade and Industry (MTI), Transport (MOT), National Development (MND), and Education (MOE).
In the aviation sector, the Sustainable Air Hub Blueprint\(^2\) and the Aviation Sustainability Programme\(^3\) focus on driving sector-wide decarbonization of airports, airlines, and air traffic management.

For logistics, the Singapore Logistics Association (SLA) has launched a Vision 2027\(^4\) for a Green Supply Chain where firms will appoint a sustainability officer who will be provided with training programs and toolkits to assist in the adoption of green solutions and reporting.

**Figure 1.1. Singapore’s Green Plan 2030**

```
THE GREEN PLAN
comprises targets and initiatives across the following five pillars

City in Nature
to create a green, liveable, and sustainable home for Singaporeans, and build up our carbon sinks by extending nature throughout our island

Energy Reset
to use cleaner energy and increase our energy efficiency to lower our carbon footprint

Resilient Future
where we build up Singapore’s climate resilience and enhance our food security

Sustainable Living
where reducing carbon emissions, keeping our environment clean, and saving resources and energy, become a way of life in Singapore

Green Economy
where we seek green growth to create new jobs, transform our industries, and harness sustainability as a competitive advantage
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Source: Singapore’s Fifth National Communication and Fifth Biennial Update Report, 2022

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Key Legislations and Policies

Since 2012, Singapore has taken significant steps to address climate change and promote sustainability through implementation of a range of legislations, policies, and regulations. Some of these key initiatives include:

- **Energy Conservation Act (ECA).** The ECA mandates that energy-intensive companies in the industrial sector monitor and report their energy use and GHG emissions annually, using methodologies in line with best practices and internationally recognized standards.

- **Carbon Tax.** Implementation of carbon pricing regulations represents one key lever to spur carbon reduction, promoting industry innovation and green growth, while maintaining overall economic competitiveness. Revenue from the carbon tax is used to support decarbonization efforts and transition to a green economy, while cushioning negative repercussions on businesses and households.

- **Climate Disclosure and Reporting.** All Singapore Exchange (SGX)-listed companies are required to publish annual sustainability reports. For certain industries, these reports must include Task Force on Climate-Related Financial Disclosures (TCFD) reports to demonstrate compliance or explain non-compliance, if any.

- **Green Building Standards.** The Building Control Act and the Building Control (Environmental Sustainability) Regulations mandate that new buildings meet specific green building standards. Additionally, the Green Mark Scheme—an internationally recognized green building rating system tailored for tropical climates—guides building design, construction, and operation for improved environmental performance.

- **Sustainable Transport.** The Land Transport Authority promotes the use of electric vehicles (EVs) through various measures, including incentives for EV buyers, installation of charging infrastructure, and electrification of public transport.

- **Waste Management.** The Resource Sustainability Act 2020 aims to reduce waste generation and promote recycling of e-waste, food waste, packaging waste, and other waste streams. It mandates waste segregation, while extending producer responsibility and promoting a “circular” economy.

- **Energy Performance and Labelling.** Under the Mandatory Energy Labelling Scheme (MELS), the Minimum Energy Performance Standards (MEPS) set the minimum energy efficiency level for regulated appliances. This helps consumers make informed decisions when buying energy-intensive appliances.

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29 Singapore was the first country in Southeast Asia to implement a carbon tax. The rate, which has remained at US$3.60/tCO2e since 2019, will increase five times in 2024 to US$18/tCO2e, further increased to US$32/tCO2e starting from 2026, and reaching US$36-58/tCO2e by 2030.

30 NCCS. Carbon Tax: https://www.nccs.gov.sg/singapores-climate-action/mitigation-efforts/carbontax/

31 Starting from 2024 (i.e., reporting for FY2023), TCFD reports will be mandatory for listed entities in high-climate risk industries such as finance, agriculture, food, forest products, and energy. This mandatory TCFD reporting will extend to SGX-listed companies in the materials and buildings, as well as transportation sectors from 2025 (i.e., reporting for FY2024).

32 The Accounting and Corporate Regulatory Authority (ACRA) and SGX Regulation have set up the Sustainability Reporting Advisory Committee (SRAC), which comprises industry, financial institutions, and accounting firms. Recommendations being proposed are for Singapore companies, including publicly listed as well as privately held entities, to adopt the International Sustainability Standards Board (ISSB) standards.

Institutional Arrangements

Climate change is a complex and multifaceted challenge that requires coordinated action across various sectors and levels of government. By adopting a “whole-of-government” approach, governments can promote the idea of departments and agencies working together towards a common goal, avoiding silos and encouraging collaboration.

In 2007, the Government established an Inter-Ministerial Committee on Climate Change (IMCCC), chaired by the Senior Minister and Coordinating Minister for National Security. The IMCCC comprises ministers overseeing environment, finance, foreign affairs, national development, transport, trade, and industry. To support the IMCCC, an Executive Committee and a National Climate Change Secretariat (NCCS) were established. In 2020, five cross-agency working groups were formed (Figure 1.2):

- Long-Term Emissions and Mitigation Working Group.
- Resilience Working Group.
- Sustainability Working Group.
- Green Economy Working Group.
- Comms and Engagement Working Group.

The NCCS was created as a dedicated unit under the Prime Minister’s Office to ensure effective coordination of Singapore’s policies, plans, and actions on climate change. In early 2023, a Government Chief Sustainability Officer (GCSO) was also appointed to oversee and coordinate strategies for the public sector. These entities play a pivotal role in fostering collaboration, knowledge sharing, and strategic planning across government bodies. By uniting diverse stakeholders under a common framework, the IMCCC and the NCCS contribute to the effective execution of Singapore’s sustainability agenda.

Figure 1.2. Inter-Ministerial Committee on Climate Change (IMCCC)

Source: Singapore’s Fifth National Communication and Fifth Biennial Update Report, 2022

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34 MSE. 2022. Appointment of Government Chief Sustainability Officer.
35 The GCSO plays a crucial role in integrating sustainability into Singapore’s policies and practices by working with agencies to develop and implement sustainability strategies, monitor progress, and ensure compliance with environmental regulations, as well as coordinate reporting of achievements of targets across agencies.
Public Sector Taking the Lead

The Government believes that the public sector must take a lead in the environmental sustainability efforts.36 Under the GreenGov.SG,37 the public sector leads the transition to peak carbon emissions around 2025 and achieve net zero emissions around 2045, five years ahead of the national target of “Net Zero” by 2050. A Public Sector Sustainability Plan 2017–202038 outlines the Government’s efforts. Every agency aligns its sustainability plan with GreenGov. SG, including the appointment of a sustainability officer to oversee its green government efforts. Emissions targets for buildings, ICT, transport, and solar deployment are set to be more ambitious than national targets.39

Annual GreenGov.SG Report and Environmental Sustainability Disclosures by Public Agencies: As part of the Public Sector taking a lead, the Government has also committed,40 starting in FY2023, to publishing an annual report to detail public sector’s efforts, progress, and plans under GreenGov.SG. The Government will start with reporting its Scope 1 and 2 emissions (see Figure 2.2 for explanation of framework), and electricity and water consumption, with reference to international standards and frameworks.41 In addition, from FY2024, all government agencies will publish annual environmental sustainability disclosures to help them track their environmental performance.

Green Procurement for the Public Sector: As a major purchaser of goods and services, the Government is enhancing its procurement policies42 to introduce environmental sustainability considerations in all public procurement by 2028. Since 2007, it has introduced resource efficiency and sustainability requirements for selected goods and services. Starting in FY2024, the Government will include more environmental sustainability considerations into its tender evaluation process for large construction and ICT tenders, which make up more than 60 percent of the value of public procurement contracts. For a start, up to five percent of tender evaluation points will be set aside for environmental sustainability. The Government also plans to progressively extend this to more sectors.43

Assistance and grants to support industry and drive energy efficiencies

Companies can face significant challenges in implementing energy efficiency projects. These include high upfront capital cost of more energy-efficient equipment or processes and difficulties related to implementing energy efficiency projects due to infrastructural constraints. To support Singapore’s transition to a green economy, various government schemes provide financial assistance, loans, and risk-sharing support for companies to become more sustainable and energy efficient.

The Energy Efficiency Fund (E2F) consists of different grants to support companies across a number of sectors in implementing energy efficiency projects.44 This includes the adoption of energy-efficient technologies, installation of energy management information systems, conducting energy assessments, and improving resource efficiency.
in facility design. The support cap has increased to 70 percent, with the grant rate tied to the carbon abatement achieved by each project.  

Small and Medium Enterprises (SMEs) can access the Enterprise Development Grant offered by Enterprise Singapore (ESG) for co-funding support of up to 70 percent of qualifying costs for the management of end-of-life ICT equipment. The Government has also issued SS 587, a voluntary Singapore Standard (ICT technology) providing a set of guidelines to manage equipment in environmentally responsible ways when they reach end-of-life.

Building industry capabilities through green skills training

Singapore recognizes the importance of lifelong learning and acquisition of knowledge and skills. In 2014, the Government initiated the SkillsFuture Movement, a national effort to empower Singaporeans to realize their full potential throughout their lives. To prepare companies and workers for transition to a greener future, the Government has rolled out various training programs at different levels, including broader-based courses, such as Enterprise Singapore’s Enterprise Sustainability Program for business executives. This also includes sector-specific programs such as Workforce Singapore’s Career Conversion Program for sustainability professionals. Some of these initiatives are highlighted in Annex A.

CHAPTER 2.
Singapore’s ICT Sector and GHG Emissions

Overview

In Singapore, the ICT or Infocomm sector is a dynamic and integral part of the country’s economy. Its highly developed Infocomm infrastructure includes resilient telecommunications networks, broadband connectivity, and a robust data center ecosystem. The country serves as a gateway to Southeast Asia and has extensive undersea cable connectivity, making it a vital node for data traffic.

Infocomm represents significant economic importance in Singapore. In 2022, the value added of the sector was US$ 24 (S$ 33) billion, representing 5.1 percent of Gross Domestic Product (GDP), up from 4 percent in 2018 (Figure 2.1, left). The sector’s contribution to Singapore’s GDP peaked in 2020 at 5.4 percent due to high use of digital technologies during COVID-19. Among the infocomm industries, information services and online marketplaces account for the largest proportion of value added at just over one-third in 2021 (Figure 2.1, right). The sector plays a crucial role in driving innovation and enabling digital transformation across Singapore’s industries. Infocomm is also the backbone of the Smart Nation initiative, which aims to “build and run a smarter, greener, and liveable city” through leveraging data and smart technologies across the country. The Infocomm Media Development Authority (IMDA)—the regulator that oversees development of the Infocomm and media ecosystems in Singapore—has been developing strategies and polices to reduce the carbon footprint of the ICT sector. The agency’s aim is to foster continued growth that is sustainable and aligned with national and global environmental and climate goals.

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47 For a breakdown of the way Singapore defines the Information and Communication Sector, see: https://www.singstat.gov.sg/modules/infographics/-/media/files/find_data/industry/notessss.pdf
Figure 2.1. Value added of the Infocomm sector (US$) and distribution by industry, 2021

![Graph showing Infocomm GDP (US$ billion) and distribution by segment, 2021.](image)

**Note:** In current prices. Converted to US$ using IMF annual average exchange rate.
Source: SingStat Table Builder [https://tablebuilder.singstat.gov.sg](https://tablebuilder.singstat.gov.sg)

### Reporting direct and indirect emissions

The GHG Protocol Corporate Accounting and Reporting Standard (2004)\(^49\) prescribes the reporting of all Scope 1 and Scope 2 emissions, and it is recognized by the Singapore Exchange (SGX) for climate reporting by publicly listed companies in their sustainability reports:

Scope 1 emissions are GHG emissions directly produced from sources owned, or controlled by, the reporting organization. These emissions include those from combustion of fossil fuels in organization-owned equipment and vehicles, as well as emissions produced from on-site industrial processes.

Scope 2 emissions are indirect emissions that result from the generation of purchased energy (e.g., electricity, heat, cooling) consumed by the reporting organization. These emissions occur during the production of the energy at the producers’ facilities (e.g., power plants) different from the locations where the energy is consumed.

Scope 3 emissions include all other indirect emissions that occur across the reporting organization’s value chain from upstream and downstream activities outside its immediate operations. As depicted in Figure 2.2, indirect upstream emissions are associated with purchased goods and services, capital goods such as buildings and equipment, fuel and energy related activities, transportation and distribution, waste generated in operations, business travel and leased assets. Indirect downstream emissions are associated with distributed or sold goods and services, transportation and distribution, processing and use of sold products, end-of-life treatment of sold products, leased assets, franchises, and investments.

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\(^{49}\) *Greenhouse Gas Protocol. Corporate Value Chain (Scope 3) Accounting and Reporting Standard.*
Pursuant to the GHG Protocol, accounting for Scope 3 emissions serves to promote “additional completeness and consistency in the way companies account for and report on indirect emissions from value chain activities.” The need for reporting Scope 3 emissions depends on the activities of the reporting organizations, as reflected by:

- The Financial Stability Board (FSB), of which Singapore is a member, states that the disclosure of Scope 3 emissions is subject to “materiality,” albeit organizations are encouraged to disclose such emissions.50
- Locally, SGX requires the reporting of Scope 3 emissions only “if appropriate.”51

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50 TCFD. 2021. Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures.
Emissions from the ICT sector

Digitalization can yield efficiency improvement, thereby contributing to environmental sustainability. Many ICT digital technologies and applications contribute to efficiency gains and help reduce emissions. Consequently, fostering an energy-efficient ICT sector is of particular importance. An analysis of the key digital technologies as enablers of emissions reduction has estimated they can deliver seven times more emissions savings compared to their own carbon footprints between 2019 and 2030.\(^\text{52}\)

The global ICT’s carbon footprint will be responsible for about 14 percent of the world’s carbon emissions by 2040.\(^\text{53}\) The International Telecommunication Union of the United Nations (UN ITU) predicts that the share of global electricity use by the ICT industry will hit 3.3 percent by 2030, and it advocates for a 50 percent reduction in GHG emissions from the ICT sector by 2030 to align with the 1.5°C trajectory set out in the Paris Agreement.\(^\text{54}\)

Singapore is characterized by high population density, a high standard of living, and heavy reliance on imported fuels to drive its economic development. In 2000, its energy demand per capita was about three times larger than the world average.\(^\text{55}\) Singapore’s overall GHG emissions were estimated at 49.7 MtCO₂e in 2020, a slight decrease from the 51.9 MtCO₂e in 2015.\(^\text{56}\) In 2018, Singapore ranked 126th of 142 countries in terms of CO₂ emissions per GDP, but was ranked 27th in emissions per capita.\(^\text{57, 58}\) Singapore is evaluating the use of cleaner energy sources such as hydrogen and nuclear power. While the country has not committed to using nuclear energy, it is building expertise and preparing itself to seriously consider options when new technology becomes available.

In Singapore, renewable energy options are lacking. In addition to having insignificant hydropower or geothermal resources, wind speeds are low, and there is limited land available for deploying solar at scale. Despite these limitations, the country’s grid is mainly gas-powered, and it has the second lowest grid emissions among Association of Southeast Asian Nations (ASEAN) members.\(^\text{59}\)

Within the global ICT sector, data centers and telecom networks will account for 75 percent of the growth of electricity demand by 2030.\(^\text{60}\) Based on the figures reported in their respective sustainability reports in 2022, the three mainstream telecommunications operators (telcos) in Singapore (SingTel, StarHub, and M1) consumed close to 1 percent of the total national grid electricity, whereas all data centers in the country consumed around 7 percent of total energy generated.\(^\text{61}\)

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\(^{54}\) ITU standard L.1470, [https://www.itu.int/rec/T-REC-L.1470](https://www.itu.int/rec/T-REC-L.1470)


\(^{57}\) Singapore’s GHG emissions in 2021 have been reported to have reached 57.7 MtCO₂e, a 9 percent increase from the 2020 levels. (The Straits Times. Nov 2023. Singapore’s 2021 greenhouse gas emissions hit record 57.7 million tonnes.

\(^{58}\) ITU. 2022. Telecommunications climate data in ASEAN.


\(^{61}\) Digital Realty, The future of data centres in the face of climate change (eco-business).
It should be noted that data centers owned by ICT companies are covered under IT Software and Services (631 Data processing, hosting and related activities; web portals), as per the Singapore Standard Industrial Classification (SSIC) 2020.\textsuperscript{62,63} Within the IT Software and Services, most emissions are from data centers operated by multi-tenant operators, cloud data centers, and data centers owned by large content providers.

### Measuring ICT Sector’s energy consumption and GHG emissions

Singapore’s Energy Market Authority (EMA) compiles energy statistics, breaking down electricity consumption by economic sector, including Information and Communication (which differs from ICT sector definition by excluding manufacturing and including broadcasting and film).\textsuperscript{64} Enterprises are assigned to sectors according to where it devotes most of its resources or from which it derives most of its income. The classification of the principal activity of the enterprise in the SES publication is based on SSIC 2020 for all reference years. SSIC adopts the basic framework and principles of the International Standard Industrial Classification of all Economic Activities (ISIC).

Electricity consumption of the ICT (Infocomm) sector grew by over 100 percent between 2017 and 2021, and its share of total electricity consumption in Singapore increased from 3.7 percent in 2017 to 8.6 percent by June 2022. At the current rate of growth, this would reach 14 percent by 2030. Infocomm is the fourth largest user of electricity after manufacturing, households, and real estate activities. GHG emissions from the Infocomm sector were 1.6 million tCO2e in 2021 (based on EMA’s grid emissions factor).

**Figure 2.3. **Electricity consumption and GHG emissions from electricity, Infocomm, Singapore


\textsuperscript{63} DCs may be classified outside of the ICT sector (SSIC 58-63), depending on the nature of their business activities.

\textsuperscript{64} EMA. Electricity Consumption. https://www.ema.gov.sg/resources/singapore-energy-statistics/chapter3
Emissions reported by Singapore’s telecommunications operators

The main infrastructure-based telecommunications operators in Singapore are Singtel, StarHub, and M1, which combined to account for 94 percent of mobile and 91 percent of fixed broadband subscriptions in 2021.\(^{(65)}\)

The three operators had been disclosing their GHG emissions voluntarily in their annual sustainability reports and setting emission targets in line with SBTi even before the Singapore Exchange (SGX) imposed the “comply or explain” rule (applicable to the telecom sector). The rule mandates that publicly-listed companies either provide climate reporting in their sustainability reports starting from the financial year commencing 2022, or provide explanation if they do not comply.\(^{(66)}\) The environmental metrics used by SGX comprise GHG emissions, energy and water consumption, as well as waste generation.\(^{(67)}\)

The operators use the GHG Protocol (as recommended by the SGX) as their emissions methodology, and employ the operational control method, reporting 100 percent of their subsidiaries energy and emissions.\(^{(68)}\) The reporting aligns with Global Reporting Initiative (GRI) disclosure 302 for energy\(^{(69)}\) and 305 for emissions.\(^{(70)}\)

In respect to geographical boundaries, reported data refers to emissions produced in Singapore. This is particularly relevant for Singtel, which has operations in Australia and other countries. Industry and corporate boundaries may present some challenges. All the three telcos have data centers. When data centers are used to support the operator’s network, their emissions and energy use should be assigned to telecommunications; otherwise, they should be assigned to data centers.\(^{(71)}\)

Operational Scope 1 & 2 emissions

As Table 2.1 summarizes, operational emissions of the three facilities-based telecommunications operators amounted to 0.203 MtCO\(_2\)e in 2021, representing 0.41 percent of the national total. Emissions from electricity consumption (488 GWh) made up 96 percent of operational emissions, representing 0.9 percent of the national total. Given that all reported Scope 1 emissions were less than 25,000 tCO\(_2\)e, none was liable for the carbon tax. Although Singtel had the highest emissions, it had the lowest emissions per revenue (21 tCO\(_2\)e/US$ million revenue) suggesting that scale played a role in carbon intensity.

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\(^{(65)}\) Based on figures reported by IMDA and company reported subscription numbers.


Table 2.1. GHG emissions reported by telecommunications operators, Singapore, 2021

<table>
<thead>
<tr>
<th></th>
<th>Scope 1 (tCO2e)</th>
<th>Scope 2 (tCO2e)</th>
<th>Scope 1+2 (tCO2e)</th>
<th>Scope 2 (% of total)</th>
<th>Electricity consumption (MWh)</th>
<th>Grid Emissions Factor (GEF)</th>
<th>Revenue US$ m</th>
<th>GHG per US$ million revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>1,239</td>
<td>26,840</td>
<td>28,079</td>
<td>96%</td>
<td>65,785</td>
<td>0.41</td>
<td>$814</td>
<td>35</td>
</tr>
<tr>
<td>Singtel*</td>
<td>4,743</td>
<td>109,535</td>
<td>114,278</td>
<td>96%</td>
<td>268,468</td>
<td>0.41</td>
<td>$5,572</td>
<td>21</td>
</tr>
<tr>
<td>StarHub</td>
<td>1,356</td>
<td>58,249</td>
<td>59,605</td>
<td>98%</td>
<td>153,356</td>
<td>0.38</td>
<td>$1,511</td>
<td>39</td>
</tr>
<tr>
<td>Total</td>
<td>7,338</td>
<td>194,624</td>
<td>201,962</td>
<td>96%</td>
<td>487,609</td>
<td>0.40</td>
<td>$7,897</td>
<td>26</td>
</tr>
</tbody>
</table>

*Company’s 2021 fiscal year ending March 2022; data refers to Singapore operations only.

Singapore’s telcos also report market-based Scope 2 emissions (Table 2.2), which refer to what emissions would be if the renewable energy they purchased were totally available to them over the national grid. In contrast, the reported Scope 2 location-based emissions refer to the emissions actually generated based on their electricity consumption. Operators calculate their market-based emissions based on Renewable Energy Certificates (RECs) they have purchased either from local or overseas renewable energy providers. For instance, in 2021, StarHub reported purchasing 8,896 MWh of RECs in 2021, of which 2,496 was from local solar and 6,400 from solar providers in Vietnam.

Table 2.2. Scope 2 market-based emissions, 2021

<table>
<thead>
<tr>
<th></th>
<th>Scope 2 location based (tCO2e)</th>
<th>Scope 2 market based (tCO2e)</th>
<th>Difference (tCO2e)</th>
<th>Electricity (MWh)</th>
<th>RECs* (MWh)</th>
<th>RECs (% of electricity consumption)</th>
</tr>
</thead>
<tbody>
<tr>
<td>StarHub</td>
<td>58,249</td>
<td>54,619</td>
<td>(3,630)</td>
<td>153,356</td>
<td>8,896</td>
<td>5.8%</td>
</tr>
<tr>
<td>M1</td>
<td>26,840</td>
<td>26,840</td>
<td>-</td>
<td>65,785</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singtel</td>
<td>109,535</td>
<td>95,684</td>
<td>(13,851)</td>
<td>268,468</td>
<td>2,000</td>
<td>0.7%</td>
</tr>
<tr>
<td>Total</td>
<td>194,624</td>
<td>177,143</td>
<td>(17,481)</td>
<td>487,609</td>
<td>10,896</td>
<td>2.2%</td>
</tr>
</tbody>
</table>

Source: Company reports (*RECs: Renewable Energy Certificates)

Singapore’s carbon tax regime allows companies to use carbon credits to offset up to 5 percent of their taxable emissions from 2024.72

Scope 3 emissions

While all three operators report Scope 3 emissions, the extent of coverage varies (Table 2.3). Only Singtel disclosed all relevant categories for FY 2021. Category 1 (purchased goods and services) is particularly relevant as it encompasses embedded emissions in network equipment such as fiber optic cable, switching stations, and mobile base stations. Much of this is manufactured abroad, so it represents a first step to measuring imported emissions.73

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72 All international carbon credits used under the carbon tax regime will need to adhere to a set of will need to adhere to a set of eligibility criteria, to ensure that they are of high environmental integrity and compliant with Article 6 of the Paris Agreement. See Singapore National Climate Change Secretariat, “Carbon Tax” at: https://www.nccs.gov.sg/singapores-climate-action/mitigation-efforts/carbontax
73 It is unclear as to why some Scope 3 emissions figures were reported by Singtel and StarHub as zero.
Some emissions associated with leased assets previously reported by M1 under Scope 1 were shifted to Scope 3. M1 explains in its report that the electricity used was under the control of the operators who leased the fixed network connection sites where M1’s equipment was located. The emissions thus fell within Scope 3, as per the GHG Protocol’s standard.

A 2020/2021 study of 40 multinational telecommunications providers found that that their Scope 3 emissions outweighed their Scope 1 and 2 emissions (75:25). In Singapore, the Scope 3 emissions with reference to the total emissions M1, SingTel, and StarHub reported were 68 percent, 97 percent, and 18 percent respectively (Table 2.3). StarHub could have captured only a portion of its Scope 3 emissions in its reports. In its Sustainability Report 2022, StarHub stated that it was in the process of completing inventory calculations for Scope 3 emissions for disclosure in future reports.

Table 2.3. Scope 3 emissions, 2021

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>Singtel</th>
<th>StarHub</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upstream activities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat 1: Purchased goods and services</td>
<td>54,360</td>
<td>2,483,126</td>
<td>8,675</td>
</tr>
<tr>
<td>Cat 2: Capital goods</td>
<td>39,602</td>
<td>1,776,125</td>
<td></td>
</tr>
<tr>
<td>Cat 3: Fuel- and energy-related emissions</td>
<td>3,424</td>
<td>687,465</td>
<td></td>
</tr>
<tr>
<td>Cat 4: Upstream transportation and distribution</td>
<td>7,324</td>
<td>18,190</td>
<td>8,475</td>
</tr>
<tr>
<td>Cat 5: Waste generated in operations</td>
<td>0</td>
<td>712</td>
<td></td>
</tr>
<tr>
<td>Cat 6: Business travel</td>
<td>337</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cat 7: Employee commuting</td>
<td>297</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Cat 8: Upstream leased assets</td>
<td>4,010</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Downstream activities</strong></td>
<td>1,046,844</td>
<td>4,320</td>
<td></td>
</tr>
<tr>
<td>Cat 9: Downstream transportation and distribution</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat 10: Processing of sold products</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat 11: Use of sold products</td>
<td>92,295</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat 12: End-of-life treatment of sold products</td>
<td>334</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cat 13: Downstream leased assets</td>
<td>127,578</td>
<td>4,212</td>
<td></td>
</tr>
<tr>
<td>Cat 14: Franchises</td>
<td>211</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>Cat 15: Investments</td>
<td>826,426</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong># of categories reported separately</strong></td>
<td>4</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total (tCO2e)</strong></td>
<td>58,915*</td>
<td>3,529,970</td>
<td>12,995</td>
</tr>
<tr>
<td>Scope 1</td>
<td>1,239</td>
<td>4,743</td>
<td>1,356</td>
</tr>
<tr>
<td>Scope 2</td>
<td>26,840</td>
<td>109,535</td>
<td>54,619</td>
</tr>
<tr>
<td>Scope 1+2 LB</td>
<td>28,079</td>
<td>114,278</td>
<td>59,605</td>
</tr>
<tr>
<td>Scope 3</td>
<td>58,915</td>
<td>3,529,970</td>
<td>12995</td>
</tr>
<tr>
<td>Total footprint</td>
<td>86,994</td>
<td>3,644,248</td>
<td>72,600</td>
</tr>
<tr>
<td><strong>Scope 3 (% of total)</strong></td>
<td>68%</td>
<td>97%</td>
<td>18%</td>
</tr>
</tbody>
</table>

Note: * Includes the following upstream and downstream categories not disclosed separately: Use of sold products / employee commuting / upstream transportation and distribution / investments / end-of-life treatment of sold products / waste generated in operations / business travel.
Source: Company reports

75 StarHub has estimated in the report that its Scope 3 emissions could account for around 79 percent of its total carbon footprint.
**Emissions Targets**

All three operators have established emissions reduction targets. Two have been approved by the Science Based Target initiative (SBTi) to ensure targets are in alignment with a 1.5-degree limit to rising global temperatures. A target needs to be set for reducing Scope 3 emissions only if they make up over 40 percent of a company’s total emissions (that is, Scopes 1, 2, and 3 combined).76

**Table 2.4. Telecommunications operators’ emissions reduction targets**

<table>
<thead>
<tr>
<th>Company</th>
<th>Targets set in 2022</th>
</tr>
</thead>
</table>
| M1      | • Reduce absolute **Scopes 1 and 2** GHG emissions 46.2 percent by 2030, from 2020 base year.  
          | • Reduce **Scope 3** emissions from purchased goods and services, capital goods, and upstream leased assets 42 percent by 2030, from 2020 base year. |
| Singtel | • Achieve net-zero emissions by 2050.  
          | • Reduce absolute **Scope 1 and 2** GHG emissions 42 percent by 2030, from 2015 baseline.  
          | • Reduce **Scope 3** emissions 30 percent by 2030, from 2015 baseline. |
| StarHub | • Achieve net-zero emissions by 2050.  
          | • Reduce **Scope 1 and 2** GHG emissions 50 percent by 2030, from 2021 baseline.  
          | • Reduce **Scope 3** emissions 25 percent by 2030, from 2021 baseline. |

Source: Respective company annual/sustainability reports 2022.

**Other environmental impacts**

While the focus of this chapter has been on GHG emissions and energy use, telecommunications operations affect the environment in other ways as well. In line with the SGX core environmental metrics, the operators also report on water use and waste generation.

The three facilities-based operators used almost a million cubic meters (m3) of water in 2021, an increase of 12.5 percent over the previous year, mainly due to a notable increase by Singtel (Table 2.4). M1 and Singtel also reported the amount of recycled “NEWater”.77 StarHub reported much lower water use than the other two operators.

**Table 2.5. Water use, 2021**

<table>
<thead>
<tr>
<th>Potable water use (m3)</th>
<th>Recycled water (m3)</th>
<th>Total water use (m3)</th>
<th>Recycled (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>20,551</td>
<td>39,190</td>
<td>59,741</td>
</tr>
<tr>
<td>Singtel</td>
<td>631,230</td>
<td>280,805</td>
<td>912,035</td>
</tr>
<tr>
<td>StarHub</td>
<td>5,800</td>
<td></td>
<td>5,800</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>977,576</strong></td>
</tr>
</tbody>
</table>

Source: Company reports.

76 Science Based Targets. Scope 3: Stepping up science-based action. [https://sciencebasedtargets.org/blog/scope-3-stepping-up-science-based-action](https://sciencebasedtargets.org/blog/scope-3-stepping-up-science-based-action)

77 NEWater is treated waste water recycled for industrial and commercial applications, as well as for replenishing reservoirs. [https://www.pub.gov.sg/watersupply/4ournationaltaps/newater](https://www.pub.gov.sg/watersupply/4ournationaltaps/newater)
The operators also reported waste indicators, although there were challenges with terminology and coverage affecting comparability (Table 2.5). Similar to water use, StarHub reported far lower non-hazardous waste than the other two operators.

**Table 2.6. Waste, tons, 2021**

<table>
<thead>
<tr>
<th></th>
<th>Total waste</th>
<th>Non-hazardous waste</th>
<th>Hazardous waste</th>
<th>Recycled e-waste</th>
<th>Customer e-waste recycled</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>171a</td>
<td></td>
<td></td>
<td>10.9b</td>
<td></td>
</tr>
<tr>
<td>Singtel</td>
<td>3,325</td>
<td>1,018</td>
<td>2,307</td>
<td>1,920c</td>
<td>35</td>
</tr>
<tr>
<td>StarHub</td>
<td>7.2</td>
<td></td>
<td></td>
<td>73 d</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>1,196</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


**Box 2.1. e-Waste**

In a 2018 NEA study, Singapore generated about 60,000 tons of e-waste annually, equivalent to the weight of 220 Airbus A380 airplanes or discarding 73 mobile phones per person, per year. However only 6 percent was recycled, and 60 percent of consumers said they did not know, or were unsure, of how to recycle their e-waste. This was expected to increase with greater spending power and new technologies constantly replacing old ones.

In July 2021, NEA introduced a regulated e-waste management system encompassing ICT equipment, including printers, desktops, monitors, mobile phones, and set-top boxes.

While the Government of Singapore has made efforts, including introducing regulations, to promote e-waste recycling, more could be done. For instance, publishing more information to make citizens and businesses more aware of how much e-waste is accumulating could increase recycling participation.

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CHAPTER 3.
Singapore’s Priority to Greening Data Centers

Overview

Data centers (DCs) are composed of servers, storage systems, and networking equipment for storing, processing, and managing vast amounts of data. They play a pivotal role in meeting the growing demand for data processing and ensuring continuity of operations in business and mission-critical IT systems. The data center lifecycle process involves design, implementation, operation, upgrades, and decommissioning. Each stage is influenced by a combination of business, technology, and operational triggers. These triggers play a crucial role in shaping the evolution and optimization of data center infrastructure:

- Business triggers are driven by changes in technology, business needs, risk management, and regulatory requirements, such as compliance in relation to sustainability and data localization.
- Technology triggers at various stages of the data center lifecycle include ICT technological advancements—such as more powerful and energy-efficient servers, storage devices, and networking equipment, cloud computing, edge computing, sensors, artificial intelligence, and machine learning—as well as advances in renewable energy solutions, power management, and cooling technologies.
- Operational triggers are events that necessitate improvement in the DC’s operation, including capacity constraints, new cybersecurity threats, sustainability requirements, performance issues, maintenance upgrades, and changing business continuity requirements.

Data centers as an economic pillar

Singapore, a global hub for technology and innovation, has recognized the importance of developing a sustainable and energy-efficient data center ecosystem to combat carbon footprint growth. The country leads Southeast Asia as a DC hub, accounting for more than 60 percent of the region’s DC market. There are more than 70 operational DCs in Singapore with total available IT capacity of about 1,000 megawatts (MW), as of 2021. Global technology companies like Facebook, Microsoft, and Amazon Web Services have built hyperscale DCs in the country to support regional business operations.

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Singapore is one of the densest DC locations in the world (Figure 3.1). According to Cushman & Wakefield's 2023 Data Centre Global Market Comparison report, Singapore tops the Asia Pacific DC ranking, and is ranked third globally. The country’s strengths lie in its market size, robust fiber connectivity, cloud availability, and the Government’s pro-business policies, which have attracted a high concentration of global tech companies.

**Figure 3.1.** Top 10 economies by connected data centers per 1 million people and organizations in connected data centers, 2022

<table>
<thead>
<tr>
<th>Connected data centers per 1 million people</th>
<th>Companies hosted per connected data center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luxembourg</td>
<td>25</td>
</tr>
<tr>
<td>New Zealand</td>
<td>18</td>
</tr>
<tr>
<td>Singapore</td>
<td>9.0</td>
</tr>
<tr>
<td>Switzerland</td>
<td>8.7</td>
</tr>
<tr>
<td>Netherlands</td>
<td>8.7</td>
</tr>
<tr>
<td>Norway</td>
<td>8.7</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>7.0</td>
</tr>
<tr>
<td>Estonia</td>
<td>6.0</td>
</tr>
<tr>
<td>Finland</td>
<td>6.0</td>
</tr>
<tr>
<td>Austria</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Note: Connected data centers refers to those where Internet traffic is exchanged among tenants. Source: PeeringDB.

Southeast Asia is also home to some of the world’s fastest-growing economies, and the region’s rapid development will accelerate its demand for data services. DCs, crucial enablers of the digital economy, help make the country a hub for high-value activities such as storage and computing for AI and machine learning (ML) applications, as well as key services such as financial services. DCs also strengthen Singapore’s position as an international connectivity hub by attracting subsea cables, and by bringing broader economic value addition aspects such as anchoring new business activities and attracting skilled manpower.

As part of its climate strategy, Singapore has placed a particular emphasis on DCs. This focus is driven by several key factors, including the significant energy consumption of these facilities, their critical role in supporting digital infrastructure, and the potential for sustainable practices to drive economic growth and attract investments.

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Environmental impacts of data centers

Global DC electricity consumption in 2022 was estimated at 240-340 TWh, or around 1-1.3 percent of global final electricity demand. Using energy efficiently is therefore critical to promote sustainable growth of the DC industry.

The efficiency of a DC hinges significantly on the cooling system used to dissipate the enormous amount of heat generated by the IT equipment such as servers and storage systems. In a typical DC, cooling systems account for up to 40 percent of total energy consumption. The cooling of DCs in a warmer tropical climate environment presents additional challenges; in Singapore, energy expended on cooling DCs is 15 to 20 percent higher than the global average.

In 2021, the over 70 operational DCs in Singapore had a combined IT capacity of approximately 1,000 MW. Scope 2 of DC emissions are calculated based on the corresponding total annual energy consumption multiplied by the Grid Emission Factor (GEF) as published by EMA for that year. In 2019, DCs accounted for approximately 5.3 percent (2.75 terawatt-hours, or TWh) of Singapore’s total electricity consumption. Against the backdrop of the COVID-19 pandemic and increased digitalization, this increased by 1.7 percentage points to approximately 7 percent (3.40 TWh) in 2020. As the pace of digitalization accelerates across all domains, the total electricity consumption of DCs is projected to increase, in line with global trends.

As DCs are large indirect emitters of GHGs in the ICT sector, contributing to 82 percent of the sector’s emissions, and are intensive users of water—for cooling, for example—it is imperative that Singapore manages the DC ecosystem for environmentally sustainable manner consistent with the country’s climate change commitments, while supporting business needs.

Development of the data center industry in Singapore

The growth of Singapore’s DC market can be divided into three phases, each with its unique focus. These phases represent the evolution and development of the DC market in Singapore over time (Figure 3.2).

Figure 3.2. Singapore’s data center industry phases

<table>
<thead>
<tr>
<th>Phase 1: Before 2010, DC infancy</th>
<th>Phase 2: 2010-18, Rapid DC growth</th>
<th>Phase 3: 2019-present, Sustainable DC growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus on availability and uptime.</td>
<td>Growth of over 10% per year.</td>
<td>Sustainability becomes a key concern; temporary pause in 2019 for new data center builds/ expansion.</td>
</tr>
<tr>
<td>Key metrics include 1-4 performance metrics of DC and uptime rating introduced.</td>
<td>Google built its 1st DC in December 2011 (live in 2013).</td>
<td>New stringent requirement of PUE 1.3 for new data centers</td>
</tr>
<tr>
<td></td>
<td>NTT launched its 1st DC outside Japan in 2012.</td>
<td>Key metrics: PUE/ emissions/ water usage/land use/ computing activities.</td>
</tr>
<tr>
<td></td>
<td>Meta announced its first data center in South East Asia in 2018.</td>
<td>Green initiatives: DC-CFA, TC</td>
</tr>
<tr>
<td></td>
<td>Some focus on sustainability.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Key metric: PUE.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Green initiatives (GMDC, S5564).</td>
<td></td>
</tr>
</tbody>
</table>

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84 DC energy efficiency is typically measured by Power Usage Effectiveness (PUE). It is calculated by dividing the total power energy consumed by a DC by the energy consumed by the IT equipment. The ideal PUE score of one indicates that all energy consumed is used solely by the IT equipment.
Phase 1: Prior to 2010, DC infancy

Prior to 2010, the DC market in Singapore was in its early stages. Singapore’s telecom market had been fully liberalized since 2000, creating a competitive environment that encouraged innovation and investment in the sector. The country’s high internet speed, widespread internet penetration, political stability, and transparent regulatory processes made it an attractive location for foreign carriers and IT providers to establish operations and data centers. During this period, most DCs in Singapore were primarily used for providing co-location and telecom services. Operators in Singapore commonly adopted the Uptime Institute’s Tier Standard, which classifies DCs into different tiers based on their infrastructure design and reliability. The tiers range from Tier 1 (least reliable) to Tier IV (most reliable), with Tier IV having an expected uptime of 99.995 percent. This phase laid the foundation for Singapore to become a regional DC hub.

Phase 2: 2010-2018, rapid DC Growth

The period 2010-2018 marked a phase of rapid growth of the DC market in Singapore. Global players such as Digital Realty, Google, NTT, and Meta started building their data centers in Singapore during this period. Singapore experienced a significant surge in the growth of DCs and quickly became the data center hub in Southeast Asia, hosting over 60 percent of the region’s data center market. The commercial DC space in Singapore was projected to increase by 50 percent from 2010 to 2015. This growing energy consumption raised concerns about energy efficiency and its impact on the environment. It was estimated that a typical large DC in Singapore consumes energy equivalent to 10,000 households. This gave rise to growing concerns for energy efficiency and environmental effects.

In the United States, the Environmental Protection Agency (EPA) submitted a report to Congress on Server and Data Center Energy Efficiency, which studied data center energy use, equipment, and opportunities for energy efficiency, laying the foundation for standardized energy performance measurement in DCs and their equipment. Following this, Singapore also began focusing on DC energy efficiency and their environmental impacts.

Phase 3: 2019-present, sustainable DC growth

In 2019, Singapore implemented a moratorium, a temporary pause on the construction of new data centers, to review policies and manage the DC sector growth sustainably, given its international climate commitments. DCs are known to consume significant amounts of electricity and water. While Singapore still welcomes investments in DCs, it now aims to be more selective of which DCs it can accommodate. Specifically, it seeks to anchor data centers that are “best-in-class” in terms of resource efficiency, which aligns with Singapore’s economic and strategic objectives. Measures will also be taken to improve the efficiency of existing DCs over time. DC operators are also expected to harness renewable energy sources or map out plans to invest in innovative technologies to offset carbon emissions. One of the measures adopted after a review completed in January 2022 mandated that DCs have a power usage effectiveness (PUE) of 1.3 or better.

In July 2022, the Economic Development Board (EDB) and IMDA lifted the temporary pause on DC build and announced the launch of a Pilot Data Centre – Call for Application (DC-CFA). Companies and DC operators intending to acquire new DC capacity in Singapore can apply through the pilot DC-CFA. The new capacity can be for greenfield (that is, new DC build) or brownfield (that is, to expand the capacity of an existing DC). There was strong

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86 Datacenter Dyamics. Feb 2012. ABB choses Singapore as entry portal into Asian DCIM market.
support and active participation by the industry in the pilot DC-CFA exercise. The proposals illustrate the continued confidence and the applicants’ commitment to innovatively grow the DC industry in a sustainable manner and strengthen Singapore’s value proposition as a key technology hub for the region. EDB and IMDA are now developing the next DC capacity allocation exercise.

Box 3.1. Data Center - Call for Application (DC-CFA)

In July 2023, out of the over 20 proposals received, four companies were supported for new DC capacity under the results of the pilot DC-CFA, with about 80 MW of new capacity awarded. The four companies were: AirTrunk-ByteDance (Consortium), Equinix, GDS, and Microsoft. These companies were chosen based on their ability to holistically meet desired outcomes and offer competitive propositions that strengthen Singapore’s position as a regional hub and contribute to broader economic objectives. Key highlights include:

- Delivers “best-in-class” energy efficient performance through comprehensive adoption of liquid cooling and energy efficient core-IT equipment. This includes meeting GMDC Platinum Certification.
- Significantly expands international connectivity by facilitating an increase in submarine cable capacity and establishing new carrier-neutral exchanges.
- Anchors key computing capacities, including AI/ML and High-Performance Compute in Singapore, while connecting with offshore DCs to complement Singapore’s capacity.
- Having significant economic commitments to Singapore beyond the direct DC investments.

Driving energy efficiencies in data centers

Recognizing the growing importance of data centers in the digital economy and the need for sustainable energy practices, the Government has implemented some notable measures to drive and promote energy efficiency in the DC market. We highlight here some key initiatives.

Green DC standard - SS564

In 2009, Singapore’s Infocomm Development Authority (IDA), now known as IMDA, launched a Green ICT program to enhance the energy efficiency and competitiveness of DCs. They partnered with government agencies and industries to create the Singapore Standard for Green DCs 564 (SS564). Published in 2011, it was considered one of the world’s first green DC standards. SS564 provides a certifiable framework for DCs to embark on their “greening” journey. A Green IT Technical Committee, under the industry-led Information Technology Standards Committee (www.itsc.org.sg), was formed to drive the development of the standard. In 2011, the committee published SS564, including a set of performance metrics and best practices guidance for the DC industry. SS564, modelled after

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90 IMDA. 14 July 2023. Four data centre proposals selected as part of pilot Data Center Call for Application (“DC-CFA”).
91 SS 564-1:2000. https://www.singaporestandardseshop.sg/Product/SSPdtDetail/ac609aee-e97c-456f-a7a1-5258a2816b45
92 SS 564-1:2020. https://www.singaporestandardseshop.sg/Product/SSPdtDetail/ac609aee-e97c-456f-a7a1-5258a2816b45
ISO 50001, seeks to guide organizations to establish systems and processes to improve the energy efficiency of their DCs:

- It provides a framework consisting of a logical and consistent methodology to achieve continuous improvement in DC facilities.
- It defines a set of performance metrics for DCs to measure their energy efficiency, providing a common benchmark to help DCs track performance and improvements.

**Green Mark DC certification**

The Building and Construction Authority (BCA)-IDA Green Mark for Data Centres (GMDC), jointly developed by then-IDA and the BCA, was launched in 2012. The Green Mark is a rating system used to determine how green a DC is. It encourages the adoption of energy efficient design, operation, and management of DCs.

SS564 provides guidelines to the DC industry on “how to go green,” whereas GMDC helps to determine “how green is the DC” and provides the recognition for industry players. It was a deliberate design decision to split the two in order to drive continuous efforts for greening DCs. DC operators that have embarked on their energy efficiency and environmentally friendly initiatives can then take the next step to assess themselves against the GMDC criteria to both get recognition for their efforts and identify additional areas of improvements.

The scheme covers DCs that are purpose-built in standalone buildings, or those that are housed in part of a larger building. It assesses DCs based on five key criteria: energy efficiency, water efficiency, sustainable construction and management, indoor environment quality, and other green features. Based on the combined scoring, the DCs will be awarded Platinum, Gold, PLUS Gold, or Certified status.

The DC landscape is changing fast, including advancement in cooling and electrical technologies/solutions, which can increase DC efficiency and promote Singapore’s “best-in-class” standards. Given this, the BCA-IMDA GMDC was revised in 2018-2019. Requirements such as Power Usage Effectiveness (PUE) and cooling were tightened to keep in line with changes to the Green Mark for Building, also updated in 2018-2019.

Over the years, GMDC has encouraged DCs in Singapore to seek the highest energy efficiencies possible internationally, even in tropical climate conditions. In the last five years, 2018 to 2023, 30 DCs have received Green Mark certification in Singapore. Going forward all new DC facilities are required to meet the highest tier of GMDC certification.

**Tropical DC (TDC) standard**

In a typical DC, cooling systems account for up to 40 percent of total energy consumption with many operators choosing to operate their IT equipment at temperatures of 22°C and below. In collaboration with the industry, Singapore introduced one of the world’s first standards for optimizing energy efficiency for DCs in tropical climates.

The standard was developed by a working group comprising domain and technical experts from industry, academia, and relevant government agencies. The standard establishes guidelines for industry to enable the operation

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of DCs at higher temperature settings while optimizing energy efficiency. This is expected to lead to cooling energy savings of 2 to 5 percent for every 1°C increase in the DC operating temperature. The new standard has been tested by several DC operators in Singapore. One of them, Digital Realty, successfully reduced its total energy usage by 2 to 3 percent by raising operating temperature by 2°C at two of its data halls, with no detrimental effects or impairments observed during the trial. On the public side, the government has also begun testing higher operating temperatures in a government data center. As a next step, to encourage greater adoption of the guidelines, IMDA is working with the BCA to update the GMDC scheme by referring to this standard.
CHAPTER 4.
Key Takeaways and Challenges Ahead

Key takeaways

Singapore is a highly urbanized, small low-lying city-state with an open economy and limited access to alternative/low-emission energy sources. Nonetheless, Singapore’s leadership has made a significant commitment to achieving net-zero emissions despite being resource-poor and fossil energy-dependent. Singapore’s perspective towards climate change serves as a useful reference for governments and policy makers facing similar challenges and constraints. The country’s commitment to tackling climate challenges and reducing GHG emissions through a “whole-of-nation” approach is notable. Other key lessons to take from Singapore’s approach include its long-term planning perspective, a public sector that takes the lead, the collaborative partnerships with industry and civil society, and the country’s emphasis on innovation and technology. We reflect here on some specific lessons to emphasize.

A. Adopting a “whole-of-nation” approach

Climate change issues cannot be addressed in silos or in a vacuum. Climate change is an issue with many dimensions that cut across the responsibilities of the public, private sectors and the society. Recognizing this, Singapore has adopted a “whole-of-nation” approach for its Green Plan 2030, reflecting a holistic commitment to address the complex challenges climate change poses.

Singapore has carefully designed a “whole-of-government” Inter-Ministerial Climate Change Committee (IMCCC), led by a Deputy Prime Minister with Ministers from key ministries, supported by an executive committee and an National Climate Change (NCC) secretariat that reports into the Prime Minister’s Office. This multi-tiered structure offers several benefits. First, having senior leadership ensures national priority and strategic direction and alignment. Second, the executive committee and the five working groups promote inter-agency collaborations and alignment to achieving the national climate change strategy and goals. Third, the appointment of a Government Chief Sustainability Officer underscores the public sector’s commitment to environmental sustainability.

Additionally, the Government went beyond a “whole-of-government” to a “whole-of-nation” effort, partnering with business, citizens, civil society, and key stakeholders to achieve the Green Plan, fostering a shared vision and collective responsibility. Reaching out and engaging the public and stakeholders through regular consultations and outreach channels and events is essential to understanding their views and garnering support and collaboration.
Through an extensive consultation process spanning 2019 to 2022, the Government garnered invaluable feedback to adjust policies and programs. These include refining long-term low-emissions strategies; developing environmental risk management guidelines for “green investments”; establishing numerous test beds and training initiatives to aid the private sector plan sustainably; introducing a progressive carbon tax to allow industries time to adapt; and increasing support to businesses for adopting sustainability practices, including emissions measurement and reporting. As part of the drive to finalize the Green Plan 2030, the Government engaged more than 1,700 members of the public and key stakeholders within a short span of six months, harnessing their expertise, innovation, resources, and support to accelerate transition to a low-carbon economy. The Government also established a US$36 million SG Eco Fund, to support co-creation of sustainability solutions (for example, climate change mitigation, waste reduction, conservation of biodiversity).

Box 4.1. An illustration of how IMDA collaborates across government and industry to achieve national targets

Collaboration among different agencies ensures that initiatives are aligned with the national plan and synergies are created. To achieve sustainable growth of data centers, IMDA—which is responsible for the ICT sector—collaborated with the National Climate Change Secretariat (NCCS) and the Economic Development Board (EDB) to review the DCs’ carbon footprint and forecasts, contributing to the plans of the Long-Term Emissions and Mitigation Working Group.

IMDA’s Green Data Centre Technology Roadmap (2013), outlining a long-term plan for the sustainable growth of DCs, resulted from collaboration with the NCCS, the research community, industry, and the National Research Foundation. The roadmap, which aligns with the national climate target, has introduced an integrated approach to the design and deployment of DCs.

The national net-zero emissions target has served as the country’s guiding principle, ensuring that initiatives from individual agencies fit into the national plan rather than being developed in isolation. This approach creates synergies, such as the development of the Green Mark for Data Centers (GMDC) based on the existing Green Mark scheme, rather than starting from scratch. Currently, IMDA is collaborating with the Building Construction Authority (BCA) to further drive GMDC adoption.

B. Balancing sustainability and economic considerations

Recognizing the importance of DCs for the digital economy, Singapore has taken a proactive approach to intervene early to manage DC growth sustainably and in line with the national climate change commitments. To prioritize energy efficiency, Singapore selectively welcomes DC investments. In 2019, the Government made a bold decision to impose a “pause” on new DC capacity.

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97 NCCS. Oct 2022. Singapore Commits to Achieve Net Zero Emissions by 2050 and to a Revised 2030 Nationally Determined Contribution; Public Sector and Jurong Lake District to Lead the Way with Net Zero Targets.
99 Speech by Minister Grace Fu. Mar 2023. Building a Green Singapore - Fostering a liveable, more sustainable nation.
100 NCCS. Oct 2022. Singapore Commits to Achieve Net Zero Emissions by 2050 and to a Revised 2030 Nationally Determined Contribution; Public Sector and Jurong Lake District to Lead the Way with Net Zero Targets.
This move aimed to prevent unchecked energy demand and carbon footprint growth, creating an opportunity for new DCs to adopt innovations and technologies for a more stringent Power Usage Effectiveness\(^{102}\) (PUE) of 1.3. These measures are intended to encourage adoption of “state-of-the-art” DC facilities, equipped with energy-efficient technologies, advanced cooling systems, efficient server infrastructure, and renewable energy sources.

It is noteworthy that Singapore’s decision to introduce a three-year pause on new DCs was made amidst the COVID-19 pandemic and rising demand for new DCs in the region and potential spillover of DC investments to neighbor countries such as Malaysia and Indonesia. Despite this complex situation, it underscores the Government’s resolve to managing GHG emissions and balancing sustainability with economic considerations.

C. Implementing timely legislative and policy measures

Government actions play a crucial role in driving system change, including the implementation of regulations and policies. Singapore offers an exemplary case of how legislative measures can effectively promote energy efficiency and reduce negative environmental effects. It introduced the Energy Conservation Act (ECA) in 2012 and amended it in 2017, establishing a legislative framework for industrial energy efficiency. The Act mandates energy efficiency requirements and energy management practices to promote energy conservation and improve efficiency. Companies investing in new or major expansions of energy-intensive industrial facilities are required to review facility designs for energy efficiency opportunities.

Additionally, Singapore became the first country in Southeast Asia to introduce a carbon price through the introduction of the Carbon Pricing Act (CPA). The carbon tax, implemented in January 2019, incentivizes emissions reductions across all sectors and supports transition to a low-carbon economy. All covered facilities are included without exemptions, ensuring that a transparent, fair, and consistent price signal is applied uniformly.

D. Adopting standards, certifications, and best practices

Besides laws and regulations, governments can drive systemic change and shape behavior by setting industry standards, certifications, and best practices that promote energy efficiencies. Singapore’s pioneering efforts in developing DC standards serve as a prime example.

In 2011, Singapore developed the Green Data Center Standard SS564. This standard provides guidelines and requirements to DC operators to ensure energy-efficient design, construction, and operation of data centers. It covers energy management, cooling systems, PUE, and adoption of renewable energy sources. In 2012, Singapore established the Green Mark Data Center certification (GMDC). This certification recognizes data centers that meet energy efficiency and sustainability criteria set by the Green Mark scheme.

Singapore’s IMDA took a decisive action by pausing construction of all new DCs for three years, 2019 to 2022. During this period, the Government assessed its policy priorities and included new stringent criteria for new DCs, one of which is achieving a PUE of 1.3 at full load. IMDA assessed that newer DCs built in recent years can achieve such stringent energy efficiency through adoption of best-in-class technologies and innovative solutions. IMDA also engaged and consulted with the DC industry in 2022 regarding the PUE criterion, and it was agreed that while a PUE of 1.3 is an ambitious and challenging goal, it remains achievable even in Singapore’s tropical climate. Driving PUE improvement and increasing energy efficiency is a pivotal decision since it contributes to the sustainable growth of DCs in the country.

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\(^{102}\) Power Usage Effectiveness (PUE) is widely used to measure the energy efficiency of DCs. The metric is calculated by dividing the total power energy consumed by a DC by the energy consumed by the IT equipment. The ideal PUE score of one indicates that all energy consumed is used solely by the IT equipment.
As a tropical country, Singapore faces unique challenges in managing the cooling requirements of data centers in a hot and humid climate. In collaboration with the industry, the country launched in June 2023 a tropical DC standard\textsuperscript{103} aimed at optimizing energy efficiency for DCs in tropical climates. The new standard is designed to guide DC operators in gradually increasing DC operating temperatures to 26°C and above. Such an increase can result in DCs benefiting from a 2 to 5 percent savings in cooling energy consumption for every 1°C increase in the DC operating temperature. In the longer term, the Government plans to chart a roadmap towards net-zero DCs powered by renewable energy sources, considering the necessary resource requirements such as land, power generating sources, and green pathways. Digital Realty, for example, has referenced this IMDA standard in a pilot and successfully increased the DC operating temperatures by 2°C at two of their 4.5 MW data halls, resulting in a reduction of approximately 2 to 3 percent total energy usage. Additionally, pilots for setting higher temperatures are undergoing in Government-owned DCs.

However, the challenge for Singapore remains on how the country can encourage owners of less energy-efficient ICT systems and legacy DCs to improve energy performance. The limited availability of renewable energy in Singapore poses another constraint for DCs.

E. Emissions reporting and targets

Regulators globally are increasingly focused on sustainability reporting, with environmental, social, and governance (ESG) reporting requirements being implemented or planned. Such reporting can enhance transparency, build trust and confidence, and identify actions to reduce emissions. Governments play a pivotal role in spearheading and enhancing the disclosure of sustainability information, ensuring that companies can uphold the same level of rigor and data quality when tracking and reporting their sustainability performance.

In Singapore, for GHG emissions calculation, sector-level Scope 2 indirect emissions from purchased electricity can be derived using the EMA’s published electricity usage and the Grid Emissions Factor. Sustainability reporting by individual organizations provides insights into Scope 1 (direct) and 3 (indirect) emissions. Various factors influence these disclosures—including sustainability reporting requirements imposed by the SGX for listed companies, regulatory authorities (for example, Green Mark application and renewal for DCs), and obligations related to sustainability-linked bonds—as well as company reputation.

The GHG Protocol Corporate Accounting and Reporting Standard (2004) provides organizations with flexibility in how they account for Scope 3 emissions. However, in June 2023, the International Sustainability Standards Board (ISSB) released two initial standards, IFRS S1 and S2. IFRS S2 (Climate-related Disclosures) mandates disclosure of Scope 3 emissions. It is likely that the GHG Protocol will update its reporting standard to align with ISSB.\textsuperscript{104} However, many organizations face challenges in quantifying indirect emissions in their value chains involving purchased and sold goods and services. As elaborated in this report, some incumbent telecom operators in Singapore have not fully accounted for their Scope 3 inventory.

In this regard, and to align with international best practices, the Singapore Sustainability Reporting Advisory Committee (SRAC) has made a timely recommendation\textsuperscript{105}: (i) reporting of Scope-3 emissions will be mandatory for all listed and large non-listed companies in 2026 and 2029 respectively; and (ii) due to the complexity of Scope-3 emissions, non-listed companies will be granted a relief period, and companies may use “reasonable and supportable information that is available to the entity at the reporting date without undue cost or effort” when measuring Scope 3 emissions, which includes the use of secondary data.


\textsuperscript{105} SRAC. July 2023. Consultation Paper: Turning Climate Ambition into Action in Singapore.
While reporting emissions provides only a snapshot of an organization’s current carbon footprint, setting climate targets demonstrates the organization’s commitment to sustainability and allows for measurable action towards those goals. In this regard, more can be done to encourage organizations in Singapore to set targets for carbon-neutrality or even achieving net-zero emissions. Regarding Scope 3 emissions targets, STBi considers them necessary where an organization’s relevant downstream and upstream emissions in its value chain account for 40 percent or more of total scope 1, 2, and 3 emissions combined.\textsuperscript{106}

**F. Government to take the lead**

The public sector taking the lead to embrace sustainable practices can accelerate progress towards national sustainability goals and inspire others to follow. By holding the public sector accountable, the Government promotes transparency and encourages continuous improvement.

One key takeaway from Singapore’s GreenGov.SG\textsuperscript{107} initiative is that the public sector can play a leading role in achieving ambitious sustainability targets. By setting their own goals to peak carbon emissions by 2025 and achieve net-zero emissions by 2045, five years ahead of the national zero emissions by 2050, the public sector in Singapore has demonstrated proactive commitment to sustainability and the importance for every public agency to be exemplary. The targets set for the public sector are even more ambitious than the national ones,\textsuperscript{108} showcasing the public sector’s dedication and resolve to drive change by taking the lead.

Public sector-specific sustainability reporting can increase transparency and hold governments accountable for their long-term interventions, enabling better-informed decision-making. For example, Singapore’s Government has committed\textsuperscript{109} to publishing an annual report that details its efforts, progress, and plans under GreenGov.SG. Starting from FY2024, all agencies will publish annual environmental sustainability disclosures, outlining their efforts, achievements, and future plans. Such disclosures will set an example for more companies to disclose their environmental performance.

Recognizing its role as a major purchaser of goods and services, the Government has also enhanced its procurement policies\textsuperscript{110} to introduce environmental sustainability considerations into tender evaluations.

**G. Partnering with industry**

Partnering with industry through consultation is a crucial step that public agencies should take when implementing regulations or initiatives to facilitate a smooth transition and minimize risks. Governments, businesses, civil society, and communities must work together. Collaboration can also lead to innovative solutions through co-creation and implementations that are practical, effective, and well-received by industry.

For example, Singapore’s IMDA has proactively partnered with industry to launch one of the world’s first standards for optimizing energy efficiency in data centers in tropical climates. The development of the standard was initiated by IMDA and involved a working group that comprised domain and technical experts from DC operators, IT equipment vendors, university academia and researchers, as well as relevant government agencies such as Gov-

\textsuperscript{106} https://sciencebasedtargets.org/resources/files/SBTi-criteria.pdf
\textsuperscript{108} The initiative also highlights the significance of reducing energy and water use by 10% from the average of the past three years. Additionally, the commitment to slash the amount of waste disposed of by the public sector by 30% from the projected generation in the next year showcases a comprehensive approach to sustainability.
During standard development over a period of 12 months, a research project jointly funded by the National Research Foundation Singapore (NRF) and industry partner Facebook collected valuable data points. The research was led by the National University of Singapore (NUS) and Nanyang Technology University (NTU) with support from IMDA. IMDA also collaborated with several DC operators in Singapore to trial this new standard.

In 2019, the Government consulted the industry to gather views and ideas before implementing a temporary pause on DCs growth. The consultation process concluded in late 2021, and the Data Center Carbon Footprint Assessment (DC-CFA) pilot was announced in July 2022. The strong industry support and active participation in the pilot underscored the importance of consultation and partnering for collaborative solutions.

In the area of sustainability disclosure and assessment, the Monetary Authority of Singapore (MAS) is collaborating with the private sector to develop and pilot blockchain-based digital utilities, which are designed to streamline the collection and use of ESG data, facilitating easier management, access and comparison of sustainability performance within and across sectors.  

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**Box 4.2. Local research on data center technology**

Local research institutions have collaborated with the industry to develop and integrate new technologies in data centers:

- The Nanyang Technological University of Singapore (NTU) partnered with Red Dot Analytics to leverage AI and data center digital twins for conducting comprehensive assessment of carbon emissions and energy usage throughout the entire lifecycle of DC operations, preventing over-design for cooling to accommodate unexpected peak loads.  

- The National University of Singapore (NUS) and Ecoline Solar developed “thermal hybrid air technology”, utilizing solar energy as a power source for cooling refrigerant in air conditioners.

- NUS worked with Equinix to test the potential for hydrogen fuel cells to be used as a power source in their DCs.

- The research institute A*STAR collaborated with local companies to create a novel heat removal solution, while also utilizing server waste heat as renewable energy.

- The local data center vendor Keppel is in the process of developing “plug-and-play” modules for floating data centers. These modules harness seawater for cooling and incorporate hydrogen infrastructure for onsite power generation.

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H. Providing support to companies to improve energy efficiency

Companies can face significant challenges implementing energy efficiency projects, including high upfront capital cost and infrastructural constraints. It is therefore important that assistance is available to help companies advance “greening” efforts, which can reap energy and cost savings and improve their competitiveness.

In Singapore, the Government has set up a package of assistance to support companies, including SMEs, to become more energy efficient. These include National Environment Agency’s (NEA) Energy Efficiency Fund (E2F), National Environment Agency. [117] Singapore Economic Development Board (EDB)’s Resource Efficiency Grant for Energy (REGE), EDB press release. Oct 2018. [118] and the Energy Market Authority (EMA)’s Genco Energy Efficiency Grant Call. These grants include support for companies to:

- adopt pre-approved energy-efficient technologies;
- install energy management information systems to monitor and manage energy consumption;
- conduct detailed energy audits to identify potential areas for energy efficiency improvements;
- conduct design workshops to improve resource efficiency (for example, energy and water) for new industrial facilities or industrial facilities with major expansion; and
- improve energy efficiency of manufacturing facilities and data centers.

I. Building industry capabilities through green skills training

The world must reduce emissions to net-zero by 2050 to avoid the worst consequences of climate change. Achieving this goal requires reskilling and upskilling of the workforce with green sustainability skills. Globally, there has been a notable shift in the demand for environmental jobs and roles, with the International Labor Organization (ILO) estimating that the green economy could create 24 million jobs worldwide by 2030. The demand for green jobs—defined as jobs that require sustainability skills—grew by 30 percent in Asia Pacific between 2016 and 2021. [119] Furthermore, the global economy is witnessing an increase in ESG regulations and disclosure requirements, which would further heighten the demand for green skills.

Countries therefore urgently need to build sustainability capacities and integrate them into their climate change strategies. The Government of Singapore has proactively established national programs to foster proficiency in energy efficiency skills within the workforce. Key programs include the Energy Efficiency Opportunities Assessor Certification Scheme (EEOAC) for certifying qualified professionals to conduct energy efficiency opportunities assessments. The Energy Efficiency Technology Centre [120] helps companies and SMEs identify and implement energy efficiency initiatives. The Centre also provides training and upskilling, and develops a pipeline of energy efficiency practitioners. A Green Skills Training program is currently in development phase, starting with roles and skills needed to support the energy sector and sustainability reporting.

J. Building regional and international partnership

Singapore recognizes that climate change is a global challenge requiring collective action. The country is a committed partner in the United Nations Framework Convention on Climate Change (UNFCCC), and it actively contributes to regional and bilateral cooperation on climate change through platforms such as the Asia-Pacific Economic Coop-

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eration (APEC)\textsuperscript{121} and the Association of Southeast Asian Nations (ASEAN) Working Group on Climate Change. The 2023 declaration by the ASEAN leaders underscores a collective commitment to addressing climate disasters and ensuring sustainable energy security.\textsuperscript{122}

The country also contributes to the international community through the Singapore Cooperation Programme (SCP), which operates a dedicated technical assistance programme focused on sustainable development and climate change. The program aims to share Singapore’s experience in these areas with other developing countries. Notably, over 150,000 government officials have attended training courses under SCP.\textsuperscript{123} Additionally, Singapore actively share its experience on sustainable development in workshops and forums organized by the C40 Cities Climate Leadership Group.\textsuperscript{124}

Collaboration enables a collective approach to tackling climate change. The sharing of knowledge, resources, and expertise on both regional and global scale enhances the effectiveness of addressing interconnected environmental challenges. Other countries can draw inspiration from these practices to strengthen their efforts in addressing the challenges of climate change.

\textbf{Box 4.3. Countries embarking on this green journey can consider a scale-up approach}

The digital economy boom in less developed countries will increase demand for ICT infrastructure, data centers and energy. It is crucial for these countries to prioritize and manage energy efficiency and GHG emissions early. For countries with limited resources and capacity, a progressive scale-up approach is recommended. Key steps to apply include:

- Prioritize climate mitigation and adaptation: Make climate action a national agenda supported by legislation, regulatory policies, and allocated public spending. This will create a framework for sustainable development and provide a clear direction for “greening” data centers, and telecom infrastructures. Moreover, governments should reconsider legislation on data localization in order to reduce the number of data centres mandated to operate within specific jurisdictions.

- Inter-agency collaboration. Establishing an inter-agency committee or task force to drive climate change initiatives will facilitate collaboration, resource allocation, planning and implementation, ensuring that these initiatives remain a priority, and that progress is tracked and reported regularly.

- Adopt international energy efficiency standards: Encourage and, if necessary, mandate adoption of international energy efficiency standards in key energy emitting activities. However, it is important to take a progressive approach that balances the need for higher energy efficiency and lower GHG emissions with financial constraints and service disruptions that may arise.

- Report energy efficiency and carbon footprints: Promote and encourage telecom and data center operators to report their energy efficiency and carbon footprints. This will create transparency and showcase how enhanced sustainability practices can reduce operational costs and create a competitive edge.


\textsuperscript{123} SCP. https://scp.gov.sg/startpublic/#/aboutUs/aboutUs

• Support renewable energy sources: Encourage and support organizations to harness renewable energy sources such as solar and wind for electricity generation. Additionally, explore innovative solutions such as using seawater for cooling data centers to reduce reliance on energy-intensive cooling systems.

• Develop viable use cases and technical assistance: Encourage development of viable use cases to demonstrate the benefits of sustainable practices in ICT and data centers. Provide assistance to organizations on technical expertise and transitioning to sustainable business practices.

• Raise Awareness and promote green skills training: Raise industry and public awareness, especially for Micro, Small and Medium Enterprises (MSMEs), organize green skills training on a wide range of topics, including energy efficiency, renewable energy utilization, waste reduction, emissions reporting, and eco-friendly practices. Hosting training programs online can enhance accessibility.

• Encourage private partnership: Governments should actively engage the private sector to drive innovation and efficiency in emissions reduction. This bottom-up approach can be particularly beneficial in countries where public finance is more limited, as it leverages the resources and capabilities of the private sector.

Navigating Challenges Ahead

Climate change is a global challenge that requires collaboration from all nations. Failure to take actions to reduce GHG emissions can lead to severe consequences. Countries that proactively prepare and adopt effective measures for emissions mitigation and climate adaptation are better positioned to respond to harms climate change will cause. Achieving a low-carbon and climate-resilient society requires collective efforts, strong political will, and innovative solutions.

While this case study on Singapore’s approach offers some valuable lessons and takeaways, it is important to acknowledge that the situation is still evolving, and key challenges lie ahead, including:

A. Scope 3 Emissions Reporting

The push for climate-related disclosure is gaining momentum worldwide due to the increasing urgency to address climate change. Research has shown businesses that comprehensively measure their emissions are more likely to reduce them. Regulatory frameworks requiring Scope 3 emissions disclosures are also progressing and evolving:

• In June 2023, the International Sustainability Standards Board (ISSB) released two initial standards, IFRS S1 and S2. IFRS S2 (Climate-related Disclosures) mandates the disclosure of Scope 3 emissions. It is likely that the GHG Protocol will update its reporting standard to align with ISSB.126

STBi requires an organization to set its scope 3 emission reduction target where its relevant downstream and upstream emissions in its value chain account for 40 percent or more of total scope 1, 2, and 3 emissions combined.127

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127 https://sciencebasedtargets.org/resources/files/SBTi-criteria.pdf
• In the EU, the European Commission has adopted the European Sustainability Reporting Standards (ESRS), and Scope 3 GHG emission disclosures are also being considered.

• Under the Securities and Exchange Commission (SEC) proposal in the U.S., listed companies would be required to disclose their Scope 3 emissions if they are material or if the companies have set targets for them.

• The Singapore Sustainability Reporting Advisory Committee (SRAC) recommends the reporting of Scope-3 emissions mandatory for all listed companies in 2026 and for large non-listed companies in 2029.  

Measurement and reporting of Scope 3 emissions is crucial in many organizations where such emissions constitute a significant portion of their overall carbon footprints. One study reported that Scope 3 emissions can account for as much as 80-95 percent of an organization's total emissions, while another study of 40 multinational telecom providers found that their Scope 3 emissions outweighed their Scopes 1 and 2 emissions (75:25). Despite this, only 12 percent of organizations surveyed in a study considered such disclosure their top priority.

One of the biggest challenges in measuring and addressing Scope 3 emissions is the complexity of the value chain, which involves purchased goods and services. Organizations must identify and measure Scope 3 emissions, set reduction targets, and develop strategies to achieve them. The absence of a harmonized, standard methodology for calculating and reporting Scope 3 emissions remains a significant challenge. The GHG Protocol provides guidance, but it can be complex and interpretation may vary. Different industries and companies may face unique challenges in defining, measuring, and reporting these emissions.

The process of gathering and compiling emissions data can also be a challenge. Obtaining comprehensive and reliable data from suppliers, customers, affiliates, and associated entities can be demanding, especially for organizations with long and complex supply chains. In many cases, the use of secondary data and assumptions is necessary, introducing additional uncertainty into the process. Besides, many organizations may lack the necessary resources to undertake these tasks effectively.

Despite these challenges, compiling Scope 3 inventory is essential for a more complete understanding of an organization’s environmental impact and sustainability efforts. Organizations should address activities that contribute most to their GHG emissions through strategies including:

• choosing suppliers that are transparent in their emissions reporting, preferably having set their emission reduction targets;

• analyzing the value chain and identifying opportunities (for example, optimizing work-flows, investing in renewables and energy management solutions) for emissions reductions; and

• purchasing recycled products, using eco-friendly and minimal packaging, as well as working with suppliers and customers to promote waste reduction, repurposing of old equipment, and recycling of end-of-life products.

134 For example, a technology company may need to consider emissions associated with the manufacturing of its products, while a retail company might need to account for emissions related to the transportation of goods. Each industry’s specific nuances can make standardization more complex.
Collaborative efforts between governments, corporations, and industry groups are crucial to develop consistent and harmonized methodologies for Scope 3 emissions calculations and reporting. Many organizations, including industry associations, are working on sector-specific guidelines and best practices. For example, ITU, Groupe Speciale Mobile Association (GSMA), and Global Enabling Sustainability Initiative (GeSI) have jointly released Scope 3 Guidance to harmonize methods for telecom operators to assess and report their Scope 3 GHG emissions, and to increase coverage, and transparency. Various voluntary reporting frameworks and initiatives are increasingly turning attention to Scope 3 emissions as a mechanism to collaborate, accelerate action, and align sector-wide decarbonization pathways.

B. Addressing the energy efficiency imperative in existing DCs

While new data centers are designed to be highly efficient, particularly best-in-breed hyperscale facilities, legacy facilities can present significant challenges. With the number of older facilities dwarfing the number of new hyperscale and co-location data centers, modernizing this market segment remains crucial to making tangible progress towards overall carbon reduction. While countries are implementing regulations to ensure that new DCs are constructed to be energy efficient, there is still a significant challenge to be met in the face of legacy, aging DC facilities, where PUEs remain around 2.0 or higher. For example, although Singapore has mandated that all new DC facilities must adhere to a stringent PUE of 1.3 and attain the highest tier of Green Mark certification, only 30 out of the existing 70 DCs have received the Green Mark certification. The challenge for Singapore remains on how the country can encourage and nudge owners of less energy-efficient ICT systems and legacy data centers into taking action to improve the energy performance of their facilities.

Article 12 of the EU Directive on Energy Efficiency (2023) stipulates that a timeframe for existing data centers to meet minimum performance standards will only be determined by 2025. Key challenges include financial constraints, technical hurdles, and service disruptions. In Singapore, the Green Finance Industry Taskforce (GFIT) has proposed a PUE of 1.5 or better for retrofitting between 2025 and 2030, with a goal of achieving a PUE of 1.3 by 2030.

Even without mandatory regulations, many DC operators are eager to address the climate challenge on their own. In Europe, for instance, a group of large DC operators created and signed a self-regulatory initiative, the Climate Neutral Data Centre Pact (CNDCP), in 2021. This pact outlines goals and targets for DC efficiency and renewable energy. It encourages DCs built before 2025 to meet the same PUE targets as new facilities (1.3 – 1.4, depending on climate) by 2030.

As organizations increasingly rely on cloud services to support their operations, the emissions from the energy consumption of the DCs hosting these services become part of the Scope 3 emissions of these organizations (under the category of “Purchased Goods and Services”). Consequently, many organizations, particularly those which

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137 For example, operators of existing DCs in Singapore are eligible to claim up to 50 percent of their qualifying expenditure on the installation of energy-efficient equipment in data centers as tax relief.
139 Many ageing data centers were built in mixed-use environments rather than purpose-built facilities. Improving their energy efficiencies may be limited by spatial constraints, outdated infrastructure and the high cost associated with retrofitting.
140 Green Finance Industry Taskforce. 2023. Identifying a Green Taxonomy and Relevant Standards for Singapore and ASEAN.
account for GHG emissions, are inclined to purchase services from providers with higher energy efficiency. DC operators are therefore incentivized to improve environmental sustainability to save operational costs, but also to boost their business reputation and gain a competitive advantage.

Governments and regulators could play a pivotal role to incentivize and encourage DC operators to publish their facility GHG emissions. Making this information publicly available promotes transparency and encourages DC operators to strive for better energy efficiency. This not only meets customer expectations but also compels DC operators to outperform their competitors in emissions reduction, leading to more ambitious sustainability initiatives.

C. Impacts of increasing demand for digital technology

Digital technology plays a crucial role in accelerating sustainability efforts. Various tools such as IoTs, digital twins, and AI-powered analytics have been used to maintain energy efficiency by providing data-driven insights, supporting sustainable optimization, and enabling collaboration across the value chain. However, there is a growing concern that this surge in digital demand may inadvertently offset the intended environmental benefits.

5G mobile connectivity

The use of the aforesaid digital technologies to boost energy efficiency requires constant communication and a massive amount of data for real-time monitoring, control, and decision-making. This necessitates a robust mobile infrastructure that provides the coverage, high capacity, and low latency necessary to drive green ICT applications. The resulting gain in efficiency not only enhances operational performance but also makes a significant contribution to mitigating energy consumption and addressing climate change. In fact, the use of 5G networks for various use cases has been estimated to enable the abatement of 330.8 MtCO2e across five industries by 2025.144

While research has shown that 5G networks could be 50 percent or more efficient per unit of data transmitted than 4G mobile networks, the increased use of 5G is likely to drive a significant rise in mobile data traffic leading to higher energy consumption and GHG emissions.145 This phenomenon known as the “rebound effect” can offset the energy efficiency gains enabled by 5G networks. Therefore, it is crucial for telecom operators to continue to invest in green technologies and renewable energy sources to achieve maximum sustainability and energy efficiency in evolving towards 5G networks. This will ensure that the rollout of 5G infrastructure does not increase GHG emissions.

Artificial Intelligence (AI)

Through advanced data analytics and machine learning algorithms, AI can help raise process efficiency and lower energy consumption. For example, smart grids powered by AI can enhance the stability and efficiency of energy distribution. In transportation, AI-driven route optimization and traffic management contribute to fuel savings and emissions reduction. In industrial plants, predictive analytics can optimize maintenance practices and minimize energy wastage. Additionally, AI-powered predictive capabilities have been used to improve cooling efficiency for data centers.146

Harnessing the capabilities of AI in these diverse applications has the potential to significantly contribute to a more sustainable and low-carbon future. A study147 showed that applying AI to all emissions can achieve overall emissions reductions of 5 to 10 percent, the equivalent of 2.6 to 5.3 gigatons of CO2e.

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144 Spiceworks. 2022. How 5G is Driving the Future of Sustainability.
147 Boston Consultancy Group. Jan 2021. Reduce carbon and costs with the power of AI.
However, the effectiveness of AI in reducing GHG emissions can vary depending on the specific use case and the efficiency of the AI system. Continuous efforts are needed to improve the energy efficiency of AI systems and ensure that the benefits of AI optimization do not negate the GHG emissions reductions it helps to achieve. Use of green energy sources and energy-efficient servers to power AI model training is particularly important. This underscores the significance of green data centers, which not only prioritize energy efficiency but also emphasize the adoption of renewable energy solutions to ensure that the advancements in AI align with environmental sustainability practices.

### D. Early adoption of sustainable energy sources

The Singapore experience has demonstrated that in countries with dense population and limited access to green energy sources due to resource constraints, it is imperative to secure sustainable energy as early as possible. While public policies can motivate various sectors and the citizens to embrace energy-efficient practices, gaining access to green energy sources is equally, if not more, important since fossil fuels are significant producers of carbon dioxide, methane and other pollutants. Efforts to minimize these emissions, along with a transition to renewable energy sources, are crucial for a more sustainable and low-carbon energy future.

While generating about 95 percent of its electricity using natural gas, Singapore has been experimenting with a number of low-carbon energy options, including harnessing geothermal energy, implementing floating solar farms, producing low-carbon hydrogen and ammonia, as well as integrating solar panels into buildings and walking paths.

Additionally, the country aims to import up to 4 gigawatts of low-carbon electricity by 2035, which will constitute around 30 percent of its projected electricity supply. It has already started importing renewable energy from Laos, and plans to further increase imports from Malaysia and Indonesia. Nevertheless, this effort is not without setbacks; for instance, a project intending to deliver solar power from Australia to Singapore through a 4,200 km submarine cable has been reported to have stalled.

Exploring alternative sustainable energy sources can be time-consuming, and their effectiveness depends on geographical constraints and urban density. Importing renewable energy can be hindered by the complexities of international energy agreements and the technical challenges of transporting and storing green energy. Despite the hurdles posed by exploring alternative green energy sources, it is imperative for countries to navigate these obstacles strategically, ensuring a sustainable and resilient energy future.

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148 The process of using algorithms to teach a machine learning model by exposing it to large amounts of data, allowing the model to learn patterns and make accurate classifications.


ANNEX A:
SINGAPORE’S GREEN SKILLS TRAINING PROGRAMS

Singapore’s Green Skills training programs are designed to empower individuals with knowledge and expertise for success in a workforce committed to sustainability and environmental awareness. These initiatives focus on cultivating skills related to green technologies, environmental conservation, and sustainable practices:

- **Energy Efficiency Opportunities Assessor Certification Scheme (EEOAC).** In 2018, the Government worked with the Institution of Engineers to jointly develop the EEOAC scheme\(^{159}\) for certifying qualified professionals to conduct energy efficiency opportunities assessments.

- **Energy Efficiency Technology Centre\(^{160}\)** was established in 2019 by the National Environment Agency (NEA) and the Singapore Institute of Technology to help companies, particularly SMEs, which may lack the resources or expertise, to identify and implement energy efficiency opportunities, train and develop a pipeline of engineering undergraduates in industrial energy efficiency, and upskill existing engineers and energy efficiency practitioners through practical hands-on training courses. SMEs benefit from a diagnosis of their energy performance and receive recommendations on areas of improvement, while concurrently having their staff trained in energy assessment skills for continual improvement.

- **Enterprise Sustainability Program (ESP)\(^{161}\)** supports companies, especially SMEs, to build capabilities and integrate sustainability into their operations, thereby enabling them to better capture new opportunities in the green economy, including by strengthening cross-sector capabilities to prepare environmental disclosures.

- **Training Program on Green Skills.** The Ministry of Trade and Industry,\(^{162}\) in partnership with SkillsFuture Singapore, has established a Green Skills Committee to develop training programs for a green economy. The Government is committed to equipping workers with skills for jobs in areas such as sustainable engineering and carbon footprint management. The committee brings together industry leaders and training providers to align workforce training with job opportunities, starting with identifying roles and skills in the energy sector and sustainability reporting. The Government will continue to work with industry to identify emerging areas for green skills.

- **Career Conversion Program (CCP) for Sustainability Professionals.\(^{163}\)** Administered by the Singapore Business Federation (SBF), the CCP supports reskilling of workers to take on business functions such as carbon management, sustainability reporting, and implementing and developing carbon projects. It also contributes to the creation of new job roles such as Sustainability Officer and Carbon Analysts and expands the current scope of work in areas such as finance, procurement, human resource, logistics, and operations.

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\(^{159}\) Institution of Engineers. 2018. *Energy Efficiency Opportunities Assessor Certification Scheme.*

\(^{160}\) Singapore Institute of Technology. [https://www.singaporetech.edu.sg/energy-efficiency-technology-centre](https://www.singaporetech.edu.sg/energy-efficiency-technology-centre)


