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CHINA STATE MECHANICAL & ELECTRICAL ENGINEERING LIMITED

香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

POLICY PATHWAYS FOR SUSTAINABLE DEVELOPMENT OF HONG KONG'S DATA CENTERS

PAE FINAL REPORT
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Content

Executive Summary

Hong Kong's rapid ascent as a global digital hub is indispensable to the booming data center business. The region's developmental political and economic policies strategically positioned Hong Kong as a core node in the Asia-Pacific's digital infrastructure, as the data center market dominated by international and local operators. However, this growth comes at a significant environmental cost. This report evaluates the current regulatory framework, which focuses on concessionary measures and energy efficiency, to identify gaps in developmental pathways; conducts a comparative case study of Singapore on regulatory measures; and evaluates policy alternatives based on effectiveness, efficiency, feasibility, adaptability, and sustainability balance.

The report proposes a structured set of policy recommendations for both short-term and long-term actions. Short-term recommendations focus on regulatory standardization and compliance, such as mandating Power Usage Effectiveness (PUE) reporting and achieving energy transparency monitoring in colocation data centers. Long-term strategies include a three-step reconfiguration plan: a temporary moratorium and tiered classification, development of green data zones and consolidation incentives, and renewable energy integration via stakeholder collaboration.

As unchecked data center growth exacerbates energy scarcity and climate impacts, Hong Kong's data center industry must evolve from being an energy liability to becoming an innovation hub where sustainability drives competitiveness in the digital age.

1 Introduction

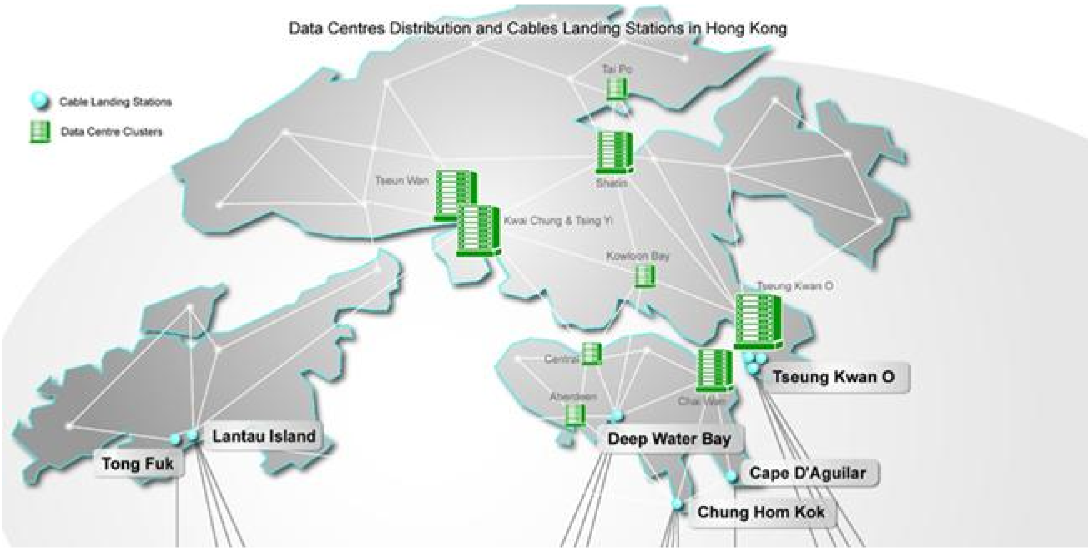
This Policy Analysis Evaluation (PAE) project is commissioned by China State Mechanical & Electrical Engineering Limited, a global leader in sustainable infrastructure and electromechanical systems, to address the dual challenges of Hong Kong's booming data center industry: rapid growth and environmental sustainability. As a key stakeholder in designing and operating energy-efficient data center infrastructure, CSCEC seeks to leverage its technical expertise to inform actionable policy solutions that align industrial expansion with Hong Kong's sustainable goals. CSCEC's role encompasses providing industry insights on electromechanical innovations and advocating for policies that incentivize green technology adoption.

In the digital era, Hong Kong, as a financial and technological hub in the Asia-Pacific region, has witnessed the large-scale expansion of data centers, which have become a cornerstone of the city's digital transformation. While existing research predominantly focuses on technical aspects of data centers, limited studies have explored broader themes such as their conceptual frameworks, societal value, spatial distribution, operational strategies, and pathways to green upgrades. There is an urgent need for a systematic policy framework to balance developmental demands with sustainability goals.

The project aims to evaluate current regulatory frameworks, identify gaps in pathways of data centers' development, and propose evidence-based recommendations to the Hong Kong government. By bridging engineering excellence with policy advocacy, this initiative strives to position Hong Kong as a "sustainable digital hub" in the Asia-Pacific region.

1.1 Data Centers in Hong Kong

Data centers are critical facilities housing computer systems and related components for data storage, processing, and management. They support technologies like cloud computing, high-performance computing (HPC), the Internet of Things (IoT), and AI, making them essential to the modern digital economy.



Graph 1. Distribution of data centers in Hong Kong (source: Hong Kong Digital Policy Office)

In the context of Hong Kong, the current market is dominated by international and local operators such as Equinix, NTT, and China Mobile, with non-local operators accounting for 54% of the share. The total power capacity of the infrastructure is approximately 307 MW, with the Tseung Kwan O region concentrating one-third of the capacity, and Goodman's Tsuen Wan West 400 MW class project is becoming the new regional benchmark[1].

Hong Kong's competitive advantage stems from its unique strategic positioning: as a 'super-contact' between China and the rest of the world, it attracts international capital with its low tax rate (corporate profits tax is only 16.5%), electricity costs that are about 20% lower than those in Singapore, and low risk of natural disasters. The strategic value of Hong Kong as the core node of Asia-Pacific's digital infrastructure will be further strengthened in the future amidst the explosion of AI arithmetic and the wave of data interconnection in the Guangdong-Hong Kong-Macao Greater Bay Area.

[1] Jones Lang LaSalle, *Hong Kong's Maturing Data Centre Market* (2023)

1.2 A Double-Edged Sword that Must be Swallowed

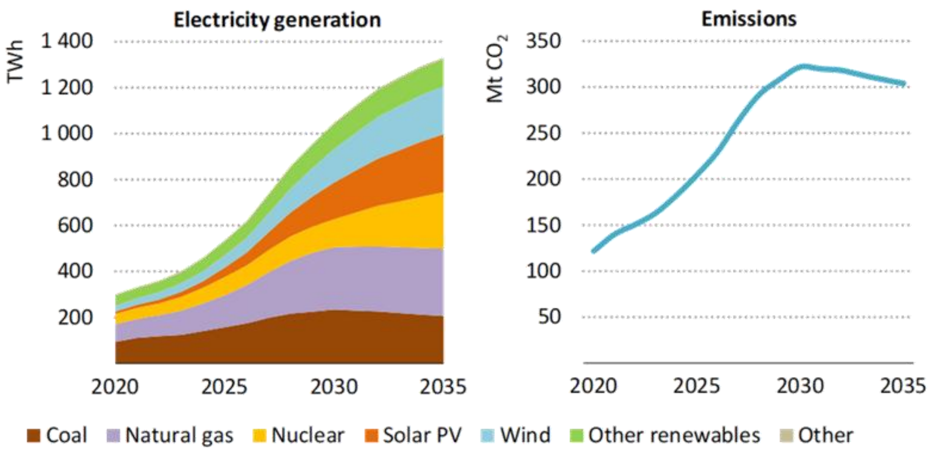
As critical enablers of next-generation information and communication technologies such as 5G, artificial intelligence, and cloud computing, data centers have emerged as the cornerstone of the digital economy era. They serve as essential infrastructure, supporting the rapid advancement and integration of these technologies into societal and economic systems.

Hong Kong’s data center industry has demonstrated strong dynamism in recent years and is gradually consolidating its position as a core hub in the Asia Pacific. As the fourth-largest data center market in the world (and the second-largest in Asia-Pacific), Hong Kong’s data center industry reached US$3.03 billion in 2023 and is expected to climb to US$5.65 billion by 2028 at a compound annual growth rate (CAGR) of 13.25%[2]. This growth is driven by multiple drivers: digital upgrades by fintech companies are driving a surge in data center demand, with demand from financial institutions expected to grow by more than 90% by 2025; generative AI and high-performance computing are accelerating the deployment of high-density facilities; and cross-border expansion by mainland Chinese companies and the spread of 5G technology continue to stimulate demand for cloud services.

However, the explosion of data centers has brought enormous energy consumption and carbon emissions. Data centers require substantial amounts of electricity due to their continuous operation of servers, cooling systems, and backup power infrastructure. Servers, which process and store vast quantities of digital data, generate significant heat and must operate 24/7 to meet global demands for cloud computing, streaming, and other online services. Cooling systems alone can consume up to 40% of a data center’s energy to prevent equipment overheating.

[2] Cushman & Wakefield, *Global Data Center Market Comparision* (2024)

Currently, the Hong Kong SAR has not disclosed specific data on energy consumption and carbon emissions in the data center sector, but its environmental impact can be glimpsed from global data.



Graph 2. Global electricity generation for data centres and the associated CO2 emissions in the Base Case, 2020-2035，source from IEA[3]

Globally, data centers' energy consumption and environmental impact are rapidly escalating, driven by technological demands and reliance on fossil fuels. In 2024, data centers consumed approximately 460 terawatt-hours (TWh) of energy, with projections suggesting this could rise to over 1 000 TWh in 2030 and 1 300 TWh in 2035. A significant portion of this energy comes from fossil fuels, leading to substantial greenhouse gas (GHG) emissions. For example, in 2020, data centers and data transmission networks generated around 330 million tons of CO2 equivalent, contributing 0.9% of energy-related GHG emissions and 0.06% of total global GHG emissions[4]. According to IEA estimates, carbon dioxide emissions from electricity generation for data centers will peak around 2030 at approximately 320 million tons of carbon dioxide, then enter a slow decline around 2035, falling to approximately 300 million tons.

[3]IEA, *Energy supply for AI – Energy and AI – Analysis* (2025)
[4] IEA, *Tracking Clean Energy Progress 2023* (2023)

The integration of AI has further increased energy demand. For instance, AI-powered tools like ChatGPT require significantly more energy than traditional search engines. While a typical Google search uses about 0.3 watt-hours (Wh) of electricity, a ChatGPT query consumes approximately 2.9 Wh. Considering 9 billion daily searches, this could require an additional 10 TWh of electricity annually.[5]

Hong Kong’s data center boom exemplifies a global dilemma: the urgent need to advance digital infrastructure while confronting its environmental toll. While the industry’s growth fuels economic competitiveness and technological innovation, unchecked expansion risks exacerbating energy scarcity and climate challenges. The path forward demands a nuanced approach—neither stifling progress nor ignoring sustainability.

[5] IEA, *Tracking Clean Energy Progress 2023* (2023)

2 Policy Review of Hong Kong

2.1 Development in Response to the Needs of Economic Growth

Based on the background of the development needs of data centers mentioned above, the policy address has also made corresponding responses. First, in the Chief Executive's 2023 Policy Address, in response to the development needs of the digital economy, it was proposed to repurpose the land in Sandy Ridge, North District, for innovation and technology (I&T) and related uses. In the subsequent 2024 Policy Address, it was announced that the I&T land allocated for data centers and related uses would be expanded from the original two hectares to ten hectares.[6]

Graph 3. Location of Sandy Ridge for Innovation and Technology (Souce: DPO)

2.2 Policy Measures

The government has introduced corresponding promotional measures in five aspects: Concessionary Measures, Energy Efficiency for Data Centre, Raised Flooring Measure, Fresh Water-Cooling Towers Scheme, and parking requirements[7]. The policy focus is on the aspect

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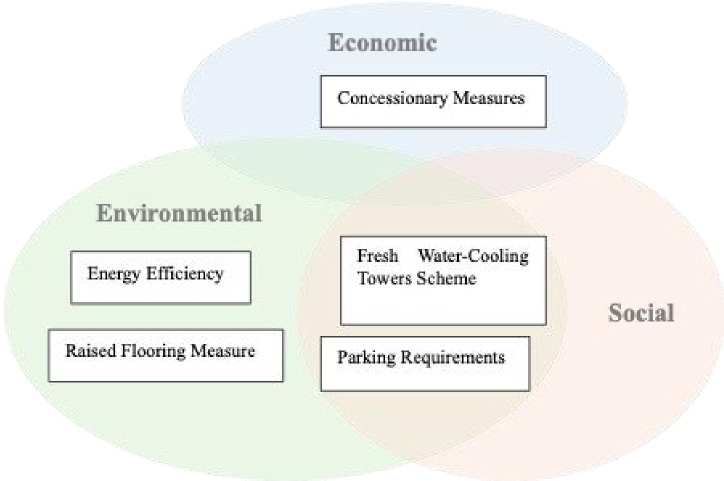
[6] Digital Policy Office (DPO). Data Centre Facilitation. The Government of the Hong Kong Special Administrative Region. https://www.digitalpolicy.gov.hk/en/our_work/digital_infrastructure/industry_development/data_centre/

[7] Digital Policy Office (DPO). Developing Data Centres in Hong Kong. The Government of the Hong Kong Special Administrative Region. https://www.datacentre.gov.hk/en/index.html

of Energy Efficiency for Data Centre. Meanwhile, the other four aspects also complement energy efficiency, jointly promoting the economic, environmental, and social development of data centers.



Graph 4. Relationship of Policies to Economic, Environment, and Social

a) Concessionary Measures

The Concessionary Measures mainly include two types of measures: the transformation of existing industrial buildings and the upgrading and development of industrial land.

The measures for the transformation of existing industrial buildings provide flexible operational space for the modernization of old industrial facilities. According to land use policies, owners of industrial buildings located in "Industrial," "Commercial," or "Other Specified Uses (Commercial)" zones may apply to convert part of their eligible buildings for data center use, with exemption from the administrative fees for the change of use.

The measures for the upgrading and development of industrial land can effectively promote the development of high-end digital infrastructure. In response to the demand for developing high-grade data centers on industrial plots, a special deed variation mechanism stipulates that the land premium will be assessed based on the actual development intensity and the high-specification data center use. This differentiated pricing approach takes into account the developers' investment costs while guiding market entities to build high-end data center facilities that meet international standards, thereby enhancing Hong Kong's competitiveness as a regional data hub.

b) Energy Efficiency for Data Centre

Data centers have always been committed to improving energy efficiency. In this area, the Hong Kong government has introduced the following targeted measures from the perspectives of regulation, guideline, and information:

Table 1. Conclusion of Energy Efficiency Policies

OFFICIALS	TOOLS	ACTIONS	INTROS
Electrical And Mechanical Services Department (EMSD)	Regulation	Building Energy Efficiency Ordinance (BEEO)	A mandatory legislation enacted in 1995 to regulate the energy efficiency of buildings through a legal framework. On 21 September 2012, the BEEO came into full operation to further specify the minimum energy efficiency standards that must be complied with in new buildings as well as major renovation works in existing buildings.
	Policy Scheme	Fresh Water-Cooling Towers Scheme (FWCT Scheme)	A measure to address water and energy efficiency in cooling systems for data centers
Digital Policy Office (DPO) - Beam Society Limited in Collaboration With a Broad Group of Reviewers Including Professionals and Industry Practitioners	Guideline	Green Data Centers Practice Guide	The Practice Guide is developed by BEAM Society Limited in collaboration with a broad group of reviewers including professionals and industry practitioners and government bodies.
Beam Society Limited	Information	BEAM Plus New Data Centers (NDC)	An assessment tool for improving energy efficiency and green performance of data centers, covering the entire life cycle.
Buildings Department (BD)	Fees Exemption	Gross Floor Area (GFA) Concessions	A measure to encourage developers to adopt environmentally friendly, energy-efficient and sustainable building designs while enhancing the productivity and safety of buildings.
	Guideline	Sustainable Building Design Guidelines	A stipulates guidelines for sustainable building design, gross floor area concessions, and energy efficiency of buildings.

c) Raised Flooring Measure

The measures for the flexibility of data center building safety regulations can effectively promote the application of efficient cooling systems. Raised flooring directly supports data centers in adopting energy-saving technologies such as hot and cold aisle containment and free cooling by allowing the raised floor to serve as a cooling air passage.

According to the Buildings Ordinance (BO), the Buildings Department requires raised floor systems exceeding 600 millimeters in height to meet the fire resisting rating (FRR) standard. However, in response to the special needs of data centers that use the raised space as an air plenum for equipment cooling, the Buildings Department has adopted a pragmatic approval mechanism, allowing exemptions from the FRR requirement in areas such as server rooms, provided that a technical justification is submitted to explain the necessity of exceeding 600 millimeters in height and that fire protection facilities in compliance with the Code of Practice for Minimum Fire Service Installations and Equipment are installed concurrently. This regulatory strategy, which combines principle and flexibility, ensures the safety baseline of buildings while creating compliant conditions for data centers to optimize airflow organization and improve cooling efficiency.

d) Fresh Water-Cooling Towers Scheme

The Fresh Water-Cooling Towers Scheme (FWCT Scheme) effectively ensures the rational use of water resources from two aspects: the inter-departmental approval process and the standardized management of project development. First, through the FWCT Scheme, the Hong Kong government implements a parallel approval mechanism for the design and installation of data center cooling towers, water supply projects, and building structures. Second, the scheme requires developers to fully consider the multiple steps involved in the application and approval process and recommends hiring experienced professionals to ensure quality and efficiency. The implementation of these measures helps to improve the operational efficiency of data centers, reduce energy consumption, and minimize environmental impact.

The necessity of the scheme lies in the fact that, by promoting the use of freshwater cooling towers, the Hong Kong government can effectively facilitate energy conservation and emission reduction in data centers, achieving sustainable development goals. At the same time, rational water resource management and efficient cooling tower design can provide a more robust operational foundation for data centers in the context of climate change and resource scarcity.

e) Parking Requirements

The operation model of data centers is different from that of other commercial and industrial buildings, and their demand for goods vehicle parking and loading/unloading spaces is unique. Data centers usually require a larger loading and unloading space, regularly receiving the transportation of equipment, spare parts, and consumables, and need a secure environment. By assessing and formulating corresponding guidelines for parking space requirements, it can be ensured that data centers have sufficient transportation and logistics support during operation, reducing the time for goods vehicles to wait outside and the occurrence of disorderly parking, thereby improving operational efficiency.

Through various policy analysis and diagrams, it can be found that the current policies are not particularly balanced in three areas, with environmental policies the most, but there is less guidance on the social value of data centers.

3 Problem Framing

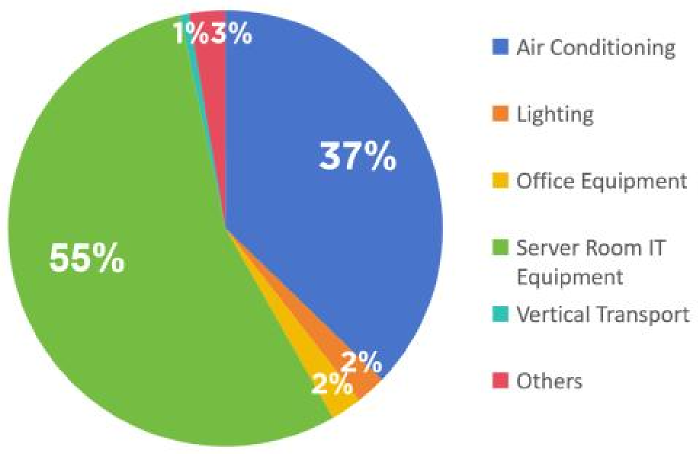
The sustainability challenges of Hong Kong’s data centre industry stem from systemic failures in market mechanisms and government governance, and the interaction of both failures brings systemic issues, making the problem more complex, which means policy lag amplifies market distortions. By analyzing these failures and issues through the market failure (negative externalities driven by profit motives) and government failure (policy gaps) and systematic issues, the root causes of unsustainable energy consumption in data centers become evident.

3.1 Market Failure: Profit-Driven Mechanisms Leads to Negative Externalities

Market failures arise when the pursuit of private economic gains overrides broader environmental interests, bringing the negative externalties. In Hong Kong’s data centre sector, this manifests in three critical ways.

The inherent design of data centers necessitates high energy consumption. According to Hong Kong’s 2024 Energy End-use Data, IT equipment in server rooms, which carry out the main operations in data centers to provide enterprises with data storage and management services, accounts for 55% of total energy use in data centers, while cooling systems contribute 37%, collectively exceeding 90% of total consumption[8]. This stems from the high power density and continuous operation requirements of IT infrastructure. For example, a standard server’s power density can be over many times that of typical office equipment, operating 24/7 to support real-time services like cloud computing and AI. Additionally, centralized layouts amplify energy intensity per unit area. This energy density positions data centers as “energy black holes” within the commercial sector.

[8] Electrical & Mechanical Services Department of Hong Kong. (2024). *Hong Kong Energy End-use Data 2024*.



Graph 5. Energy Consumption in Data Centre Segment by End-use

To ensure service continuity, data centers prioritize physical redundancy over software-based resilience. The 2024 Annual Outage Analysis Report reveals that 73% of global operators rank hardware redundancy (e.g., dual power supplies, backup generators) as their top reliability strategy[9]. Multi-tenant data centers (MTDCs) often employ redundant hardware designs to mitigate downtime risks, such as deploying clusters of 8–10 coolant distribution units (CDUs) organized into pods. In such configurations, each CDU typically handles only 10–15% of the total cooling load. This setup allows other units to seamlessly compensate if one fails due to pump malfunctions or other issues. While this redundancy enhances reliability, it significantly increases energy consumption. For instance, maintaining multiple underutilized CDUs in parallel leads to excess power use even during normal operations[10].

Operators favor technologies with minimal upfront costs over long-term efficiency. Air cooling, compatible with existing infrastructure and cheaper to retrofit than liquid cooling,

[9] Uptime Institute. (2024, March). Annual Outage Analysis 2024. Retrieved from Uptime Institute website: https://uptimeinstitute.com/resources/research-and-reports/annual-outage-analysis-2024

[10] Vertiv. (2025, January 14). High-density cooling: A guide to advanced thermal solutions for AI and ML workloads in data centers. Retrieved May 21, 2025, from Vertiv.com website: https://www.vertiv.com/en-us/about/news-and-insights/articles/educational-articles/high--density-cooling-a-guide-to-advanced-thermal-solutions-for-ai-and-ml-workloads-in-data-centers/

remains the main choice for Hong Kong's data centers. However, air cooling consumes 40% of total energy, compared to liquid cooling's potential to reduce this to below 10%[11]. This paradox highlights structural flaws in market incentives: an IDC 2023 survey found that environmental sustainability ranks 2nd among operator priorities, trailing behind financial management[12]. Additionally, vendor lock-in reinforces path dependency. Traditional air-cooling suppliers, for instance, bind clients through long-term service agreements, imposing high switching costs for operators seeking upgrades.

3.2 Government Failure: Policy Gaps

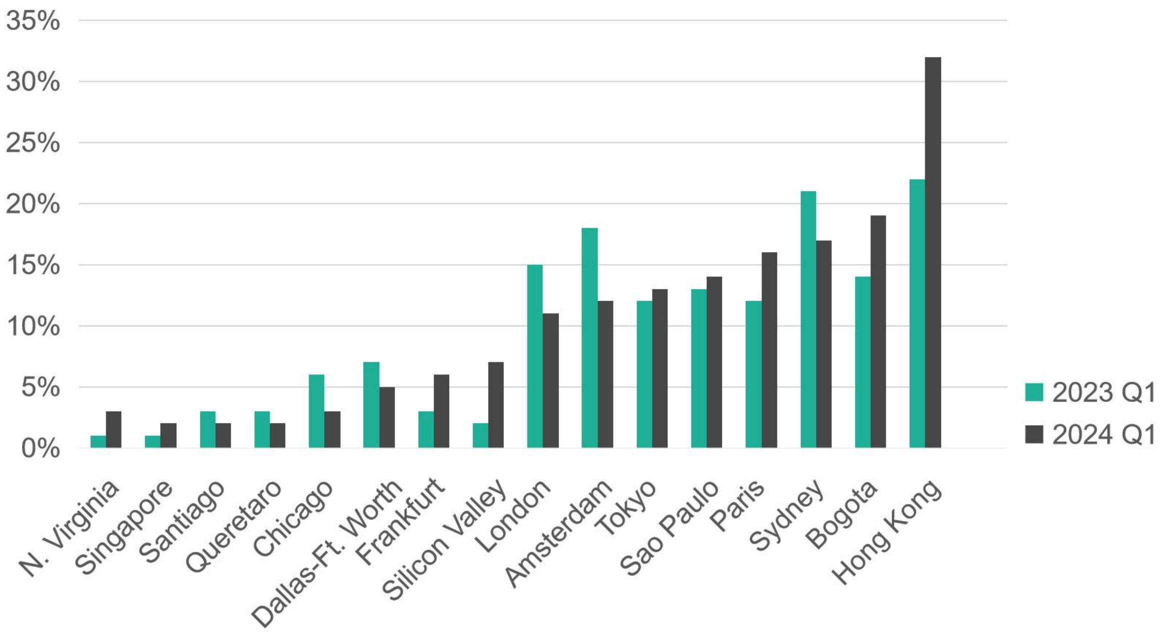
Government failures further exacerbate the challenges faced by Hong Kong's data center industry by regulatory and incentive policy gaps. Hong Kong's regulatory framework fails to address data centers' unique energy demands which is evident in the lack of specificity and enforceability of existing policies to control the environmental impact brought by data centers. For example, Hong Kong's Building Energy Efficiency Ordinance (BEEO) does not provide targeted or binding standards for data centers, unlike Singapore's Green Mark Scheme, which mandates strict Power Usage Effectiveness (PUE) targets of ≤1.3 by 2030. Similarly, Hong Kong's lack of targeted incentives perpetuates data centers' reliance on legacy energy systems. For example, The FiT caps subsidies at 1 MW, while a single large data center's peak load can exceed 50 MW, rendering the policy irrelevant.

[11] Department of Resource Conservation and Environmental Protection . (2020). Liquid-cooled thermal conductivity and energy-saving technology for electronic equipment. Retrieved from Ndrc.gov.cn website: https://www.ndrc.gov.cn/xwdt/gdzt/qgjnxcz/jnjsyy/gejnjs/202006/t20200626_1232083.html

[12] Graham, S. (2024, September 23). Data Centers and Our Climate | IDC Blog. Retrieved from Idc.com website: https://blogs.idc.com/2024/09/23/data-centers-and-our-climate/

3.3 Systemic Challenges: Market-Government Interaction Failures

According to the CBRE report "Global Data Center Trends 2024[13]", Hong Kong's data centre market has seen a significant increase in supply, outpacing demand and resulting in a vacancy rate of over 30%, which means the percentage of available space in a data center that is not currently being used or leased, ranking the first place in the world's market.



Graph 6. Data center Vacancy Rate by Market

This over-supply trend is driven by several factors, including speculative investments and rapid infrastructure expansion without adequate consideration of market demand, which means that many global digital companies have adjusted their data centers' strategy. For example, Microsoft has walked away from data center projects to the tune of 2GW due to an oversupply relative to its near-term demand forecast[14]. However, the Hong Kong government

[13] CRBE. (2024). Global Data Center Trends 2024. Retrieved from Cbre.com website: https://www.cbre.com/insights/reports/global-data-center-trends-2024

[14] Butler, G. (2025, March 27). Microsoft cancels up to 2GW of data center projects, says TD Cowen. Retrieved from Datacenterdynamics.com website: https://www.datacenterdynamics.com/en/news/microsoft-cancels-up-to-2gw-of-data-center-projects-says-td-cowen/

is still trying to attract investments in data centers, showing its ambitious expectation of developing the digital economy with the data center industry as one of the pillars. So in a word, demand is over-estimated by Hong Kong’s market, and policy lags that consistently encourage the expand of data center in Hong Kong amplify the market distortions, leading to the over-supply of Data Centers in Hong Kong.

4 Case Study of Singapore

Here is a comparison and case study between Singapore and Hong Kong. This section first explains Singapore's ranking in terms of data centers and sustainability, and shows the common issues faced in developing data centers between Singapore and Hong Kong. It then shows the history of Singapore's data center development and the characteristics of each stage. then concludes with a summary of policy initiatives in Singapore that are of relevance and summarize recommendations that can be useful for Hong Kong data centers.

4.1 Rankings and Condition

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 Singapore's focus on sustainable development while maintaining continued competitiveness.

At the same time, Singapore has also performed remarkably well in the data centers. According to data from Cushman & Wakefield's Global Data Center Market Comparison Report 2023, Singapore's data centers are ranked first in Asia Pacific and third in the world. Its data centers account for more than 60% of the Southeast Asia data center market, and it is the absolute leader in the region with a strong presence. There are more than 70 operational DCs in Singapore with total available IT capacity of about 1,000 megawatts (MW), as of 2021[15]. Global technology companies like Facebook, Microsoft, and Amazon Web Services have built hyperscale DCs in the country to support regional business operations. And as a city-state with a highly developed economy, a small area, a large population, and a proximity to the sea and a low latitude, Singapore shares numerous similarities with Hong Kong in

[15] Cushman & Wakefield. 2023. *Global Data Center Market Comparison.* https://www.cushmanwakefield.com/en/insights/global-data-center-market-comparison

terms of its many geographical and human characteristics. Therefore, the case review of Singapore’s policy on the construction and management of data centers will be highly helpful for Hong Kong.

4.2 Development of Singapore’s Data Centers

Overall, the development of data centers in Singapore can be divided into three main stages, and its characterization and main policy are as followed:

Stage I: Pre-2010, Infancy of Data Centers

(1) A liberalized telecommunications market created a competitive environment for the private sector that is conducive to innovation and investment.

(2) Operators adopted the Uptime Institute’s Tier standard, which categorizes DCs into different tiers based on infrastructure design and reliability. The tiers range from Tier 1 (least reliable) to Tier IV (most reliable), with Tier IV having an expected reliability of 99.995 percent.

This phase laid the foundation for Singapore to become a regional DC hub.

Stage II: 2010-2018, Rapid Growth of Data Center

(1) Global players such as Digital Realty, Google, NTT and Meta have begun to set up data centers in Singapore, which is fast becoming a Southeast Asian data center hub.

(2) The increase in data center sites, huge utility consumption, and high carbon emissions raised public concerns about energy efficiency and environmental impact.

(3) The government began to focus on standardizing the energy performance of data centers and their equipment, as well as their environmental impact, and has begun to develop rules to do so.

This phase saw the rapid growth of data centers in Singapore, and their impact on the environment is gradually drawing attention.

Stage III: 2019-2022, Suspended development and Challenged Position

(1) In 2019, Singapore implemented a moratorium on the construction of new data center facilities in response to its public concern about heavy consumption of electricity and water.

(2) Meanwhile, the explosion of AI has led to increased demand for data centers. Many companies are turning to Singapore's neighbors to build new data centers. Singapore's central position in Southeast Asia's data centers faced challenge.

This phase witnessed Singapore's focus on the environmental damage caused by data centers, but it also proved that neglecting data center construction in the age of AI is not advisable.

Stage IV: 2022-now, New Rules and Sustainability Development

In 2022, the Economic Development Board (EDB) and Info-comm Media Development Authority (IMDA) lifted the temporary pause on DC build and announced the launch of a Pilot Data Centre-Call for Application (DC-CFA) to encourage companies that use energy more efficiently to build data centre.

In the new policy, , IMDA set stricter standards for new DC entries, requiring a PUE of 1.3 at full load[16]. And the companies that were allowed in 2023 have made commitments to enhance Singapore's telecommunication connectivity, provide high-performance computing capabilities, and benefit Singapore's overall economic development, in addition to demonstrating their own efficient use of energy in the construction of data centers. This demonstrates the Singapore government's consideration of various criteria in judging data center builders[17].

[16] EDB.2022 https://www.edb.gov.sg/en/business-insights/insights/singapore-pilots-sustainable-way-to-grow-data-centre-capacity.html

[17] EDB.2022 https://www.edb.gov.sg/en/about-edb/media-releases-publications/edb-and-imda-launch-pilot-data-centre-call-for-application-to-support-sustainable-growth-of-data-centres.html

This phase exhibits the Singapore government's focus on sustainable data center development.

Conclusion

After the above summary of the stages of data center development in Singapore, it can be noted that data centers play an important role in today's competitive cities and it would be unwise to limit the development of data centers altogether. The government should adopt more intelligent policies to find a balance between data center development and sustainable development.

4.3 Effective experience in data center development in Singapore.

Each of these three phases of data center development has its own development characteristics. The Singapore Government has also gained a lot of helpful experience during this period, especially includes timely legislative, targeted standards, and emissions transparency reports. These key efforts have had a positive impact as the Singapore government promotes the sustainable development of data centers, the analysis are as followed:

4.3.1 Timely legislative

(1) In 2012, the government introduced the Energy Conservation Act (ECA), which was amended in 2017. The Act sets out energy efficiency requirements and makes intensive industrial facilities subject to scrutiny for companies investing in new energy sources.

(2) In 2019, the government implemented the Carbon Pricing Act(CPA), making it the first country in Southeast Asia to introduce a carbon tax. The bill imposes a carbon-loading levy on all industries to promote emissions reductions.

4.3.2 Targeted standards

(1) In 2011, Singapore developed the Green Data Center Standard SS564[18]. 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.

(2) In 2023, the government introduced the Tropical DC Standard 103[19], the first energy efficiency standard for big data centers in the tropics. In the past, data centers typically are allowed to operate at 22 degrees and below because they were often built at high latitudes.The new standard requires DC operators to progressively increase DC operating temperatures to 26°C and above. For every 1°C increase in such DC operating temperature, DCs will benefit from cooling energy savings of 2% to 5%. In the long term, the government plans to develop a roadmap towards net-zero DCs powered by renewable energy.

4.3.3 Sustainability Reporting Requirements

Singapore requires all companies listed on the Singapore Exchange to publish annual sustainability reports[20]. These reports must include environmental indicators on greenhouse gas emissions, energy and water consumption and waste generation. And from 2024 onwards, listed companies in certain high-climate-risk industries will be required to report, or explain why they are not reporting as recommended by the Task Force on Climate-related Financial Disclosures (TCFD) .

[18] SS 564-1:2020. https://www.singaporestandardseshop.sg/Product/SSPdtDetail/ac609aae-e97c-456f-a7a1-5258a2816b45

[19] IMDA. 2023. *IMDA introduces sustainability standard for data centres operating in tropical climates.* https://www.imda.gov.sg/resources/press-releases-factsheets-and-speeches/press-releases/2023/imda-introduces-sustainability-standard-for-data-centres-operating-in-tropical-climates

[20] TCFD. 2021. *Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures.*

4.4 Useful Lessons in Singapore Case

The above analysis of the Singapore case can provide the following lesson for the development of data centers in Hong Kong:

4.4.1 the DC construction is extremely important

Singapore's three-year pause in the construction of new data centers has led to a challenge to its position at the heart of data in Southeast Asia by other Southeast Asian countries. This example should make Hong Kong realize that while sustainable development is important, data center development should also be simply abandoned, especially in this fast-emerging AI Age.

4.4.2 Standard Setting should meet the local condition

Singapore, like Hong Kong, is located in a low-latitude region, and its data center construction and operation face similar adverse environments of high temperatures, humidity and proximity to the sea.The current standards for data centers in Hong Kong are fragmented and lack specificity, making it difficult to reflect the geographical characteristics of lower latitudes and providing weak guidance for the construction of data centers. Hong Kong can learn from or draw reference from Singapore's tropical data center standards, taking into account the local climate and geography, to provide more targeted guidance on local data center construction standards.

4.4.3 upgrade can be gradually taken by application policy

Data center development in Singapore started earlier. To encourage companies to be greener in their data center construction and operations, Singapore has put a moratorium on approving the construction of new data centers for the period 2019-2022 and looked at stricter standards for the period. After lifting the moratorium on new data center construction, Singapore encourages the most efficient companies to build through the Pilot Data Centre-Call for Application (DC-CFA), which is a progressive approach to improving the overall green level of data centers. This policy of incrementally raising the level of energy efficiency in new data centers through an approval system has implications for Hong Kong.

4.4.4 Regular sustainability report can be required

Singapore's experience has shown that it is helpful to require data center companies to disclose their sustainability reports on a regular basis, so that they can focus on their use of water, electricity and land, their greenhouse gas emissions, and their utilization of resources. It is important to note that the reporting requirements for companies do not require them to disclose private data obtained by the data center, or company business secrets such as technical details, but focus solely on the data center's use of resources and pollution emissions. Therefore this is not an invasion of personal privacy or the company's trade secrets.

5 Alternatives

5.1 Interview Design

We conducted semi-structured interviews with industry practitioners, academics, and policymakers, to help us explore sustainable best practices from multiple perspectives and stakeholders. We interviewed practitioners from China State Mechanical & Electrical Engineering Limited (CSCEC) to gain technological insights from industry insiders. Ian Soares, a PhD researcher at HKUST whose work focuses on the intersection of sustainability and technology, specifically the relationship between digitalization and decarbonization. And Professor Elvis Au, who has over 32 years of experience in the Hong Kong government, focuses on environmental issues, sustainability, energy, and climate change. During the interview, we focused on three main aspects- current challenges in data center energy consumption, their research outcome implications, and solutions to solve these problems. CSCEC pointed out the focus of the data center in financial profit rather than taking sustainability green energy development into account when developing. Ian highlighted Hong Kong’s lack of strict environmental targets for data centers, unlike Europe’s 2023 Energy Efficiency Act. He suggested setting mandatory PUE thresholds, enhancing transparency through energy consumption reporting, innovating cooling technologies like Microsoft’s underwater systems, and optimizing land use with designated zones and tax incentives.

Elvis Au presented a game-changing point of view. He posits that the core problem is not about energy consumption but is an economic one. According to Elvis Au, the key question is whether the economic, social, and environmental benefits of data centers outweigh their costs and environmental impacts. If data centers cannot demonstrate that they can provide a net positive contribution to society and the economy, then what we need to do is to question their efficiency and the existence of these facilities. This perspective shifts the focus from merely improving energy efficiency to a broader evaluation of the role and necessity of data centers within the economic and social framework. Authorities should reevaluate data center necessity through cost-benefit analyses to justify their existence. He proposed reducing their number if unsustainable, relocating them to renewable energy-rich areas like offshore wind farms, and using clean energy.

To reconcile these perspectives, we employ categorization and thematic analysis, organizing their insights into three core themes: economic and social trade-offs, technological and environmental, and their positions on policy. We then specified them into themes structure including addressing regulatory and compliance measures; leverage existing renewable resources and procurement; fundamental analysis and strategic reconfiguration of data centers.

5.1.1 Categorization and Thematic Analysis

All interviewees highlighted the absence of mandatory energy efficiency targets (e.g., Power Usage Effectiveness/PUE thresholds) as a critical barrier. Ian noted that Hong Kong lags behind jurisdictions like the EU and Singapore, where laws such as the 2023 EU Energy Efficiency Directive enforce compliance. Furthermore, the prevalence of multi-tenant data center mode complicates energy monitoring. Ian emphasized that tenants often withhold energy data due to competitive concerns, creating opacity in shared facilities.

5.1.2 Economic and Social Trade-offs

It was a surprising direction when Elvis Au urged a fundamental reassessment of data center necessity. The fundamental logic lies in the fact that in order to solve the energy consumption problem, we need to look at it at a higher level, which is the role and necessity of data centers within the economic and social framework. He proposed a Social Cost-Benefit Analysis (SCBA) to evaluate whether economic benefits (e.g., fintech growth) outweigh environmental costs (e.g., carbon emissions). Second, high land prices in Hong Kong incentivize inefficient use of industrial zones for data centers. Ian stressed that without zoning reforms, energy-intensive facilities will proliferate in suboptimal locations.

5.1.3 Technological and Environmental Barriers

Hong Kong's tropical climate exacerbates energy use, with cooling systems consuming ~40% of the total energy, according to CSCEC. They also emphasized that the usage of cooling systems is one of the major energy consumption in data centers, despite the existence of water-cooling system technology. Ian cited Singapore's adoption of advanced cooling technologies (e.g., Microsoft's underwater data centers) as a model. And because of Hong Kong's current condition of heavy reliance on CLP Holdings, which sources 70% of energy from non-renewable mainland grids, this severely hindered decarbonization efforts in Hong Kong.

Based on the real-life experience and suggestions given by our interviewees, we summarize the most crucial field of improvements targeting policies for the Hong Kong Data Center.

5.2 Policy Directions

5.2.1 Economical Development: Strategic Reconfiguration and Tiered Incentives

The current imbalance in Hong Kong's data center market—characterized by over-supply, low utilization rates, and policy lag—demands structural reforms. *A Strategic Reconfiguration of Data Centers* is proposed to phase out low-efficiency facilities and consolidate operations into hyper-efficient hubs. For instance, merging 12 Tier 3 centers could reduce energy use by 60%, as demonstrated in pilot projects, while repurposing decommissioned sites (e.g., Sham Shui Po's aging centers[21]) into renewable microgrids or

[21] *ASD Hong Kong – Sham Shui Po Data Centre Complex – Sham Shui Po.* (n.d.). Market Research Reports & Consulting | GlobalData UK Ltd. https://www.globaldata.com/store/report/asd-hong-kong-sham-shui-po-data-centre-complex-sham-shui-po-profile-snapshot/

community tech hubs. Complementing this, *Tiered Subsidies* would categorize centers into Tier 1 (critical infrastructure, e.g., Hong Kong Stock Exchange servers), Tier 2 (high-energy commercial providers), and Tier 3 (redundant facilities). Tier 1/2 operators could access subsidies for retrofits, while Tier 3 sites face penalties or phased shutdowns. A pilot targeting 10 Tier 3 centers by 2026 could free 50,000 sqm of urban space for green infrastructure, aligning with Hong Kong's 2050 carbon neutrality goals. These measures address both market inefficiencies and policy gaps, ensuring economic growth aligns with sustainability.

5.2.2 Sustainable Energy Development: Leveraging Renewable Innovations

Hong Kong's reliance on non-renewable energy (70% of energy for cooling) and outdated air-conditioning systems starkly contrasts with global leaders like Singapore, which uses liquid immersion cooling to slash cooling energy by 40%[22]. To bridge this gap, *Leveraging Existing Renewable Partnerships* is critical. Adopting liquid cooling technologies (e.g., gel-based systems tested in Singapore) and submerged data centers in maritime zones (modeled after Microsoft's "Project Natick") could harness seawater for passive cooling. Onshore, retrofitting high-rise data centers with solar-integrated curtain walls (thin-film photovoltaic panels) could generate 15–20% of their energy needs, as seen in South Korea[23]. Waste-heat reuse systems, such as redirecting thermal energy to heat the TKO Sports Complex via absorption chillers (mirroring Stockholm's 80% emissions reduction model[24]), further enhance efficiency. Public-private partnerships with firms like CLP Holdings could accelerate pilot projects, while cross-border PPAs with Guangdong Province (e.g., securing 150 MW wind/solar contracts) would diversify Hong Kong's energy mix. These innovations, supported by R&D grants, position Hong Kong as a leader in Asia's green tech transition.

[22] *Thermo-Fluid & Energy*. (n.d.). School of Mechanical and Aerospace Engineering. https://www.ntu.edu.sg/mae/research/research-focus/thermo-fluid-energy

[23] Thompson, V. (2023, August 31). *New techique to color flexible thin-film BIPV, VIPV panels*. Pv Magazine International. https://www.pv-magazine.com/2023/08/31/new-techique-to-color-flexible-thin-film-bipv-vipv-panels/

[24] Zealux. (2025, February 21). Heat Pumps Unlock 80°C District Heating Networks: Transforming Data Center Waste Heat into 40% Energy. *Zealux*. https://zealux.com/heat-pumps-data-center-waste-heat/

5.2.3 Government Regulatory Measures for Society: Binding Standards and Collective Governance

To counteract market failures (e.g., profit-driven externalities) and government inefficiencies (e.g., lax PUE standards), a dual regulatory framework is essential. First, *Binding PUE Standards* would mandate a phased reduction from ≤1.5 by 2030 to ≤1.2 by 2035[25], enforced through compliance upgrades like server virtualization. Facilities exceeding carbon budgets must offset emissions via verified renewable investments (e.g., procuring wind/solar credits). Second, *Transparency and Collective Governance* requires collocation operators to disclose aggregated energy data (e.g., kWh per facility) through a tiered framework, balancing confidentiality with accountability. The proposed “Hong Kong Data Sustainability Standard” would certify centers meeting PUE compliance, ≥30% renewable energy use by 2035, and circular practices (e.g., hardware recycling), incentivized through tax breaks or fast-tracked permits. Additionally, zoning reforms designating “Green Data Zones” in coastal areas (e.g., Tuen Mun) offer 50% land premium discounts for projects with PUE ≤1.3, mirroring South Korea’s industrial incentives. These measures ensure systemic accountability, driving Hong Kong toward a resilient, low-carbon digital economy.

[25] *What is PUE in Data Centers? | Supermicro*. (n.d.). https://www.supermicro.com/en/glossary/pue-for-data-center#:~:text=A%20good%20PUE%20for%20a,to%201.2%20or%20even%20lower.

6 Policy Alternatives Evaluation

In this chapter, we conduct a thorough evaluation of the policy alternatives designed to enhance the energy consumption sustainability of Hong Kong's data centers. Using the five criteria—effectiveness, efficiency, feasibility, adaptability, and sustainability balance—we perform a qualitative assessment of both the current policies and the policy alternatives. Each criterion is assigned a specific weight based on its relative significance in driving sustainable development within the data center industry. By evaluating the policies against these weighted criteria, we aim to calculate an overall score for each policy. The goal is to provide a clear and objective comparison of the policy options, offering valuable insights for decision-making and policy formulation in promoting sustainable energy consumption in Hong Kong's data center.

6.1 Criteria for Evaluating Policy Alternatives

6.1.1 Effectiveness

Effectiveness means whether the policy successfully solves market failures, government failures, and systemic issues mentioned in the problem section. It requires the policy to address the core causes of the problem and achieve planned results. For example, it evaluates whether the policy has effectively fixed profit-driven high energy use and the conflict between profit goals and environmental benefits in the market. It also considers whether the policy has improved renewable energy infrastructure, boosted cooperation between the government and the market, and solved policy delays to prevent market problems and wrong resource use.

6.1.2 Efficiency

Efficiency evaluates the cost-benefit ratios and rationalization of resource allocation of the alternatives. Policy benefits can be in social, economic, and environmental aspects. Economically, the policy can help the data center industry and related fields grow, create jobs, and increase economic growth. Socially, it can enhance public welfare by improving air quality and public health. Environmentally, it helps reduce carbon emissions and protect natural resources. It contributes to a greener and more sustainable future. Costs mainly include spending on developing energy-saving technologies, initial investment for transformation, and expenses to implement the policy.

6.1.3 Feasibility

Feasibility evaluates the regulatory complexity, stakeholder acceptance, and technological readiness of alternatives. Policies should consider existing rules and avoid making them too complicated, which could increase costs for data centers to follow and for regulators to enforce. The policy must think about the interests of different groups, such as data center operators, energy suppliers, equipment makers, and users. It should try to get wide support from these groups to reduce resistance when implementing the policy. Also, the policy should be based on the current technology level of Hong Kong’s data centers and the availability of energy-saving technologies.

6.1.4 Sustainability Balance

Sustainability balance evaluates whether the policy meets the economic, social, and environmental "triple bottom line." Economically, the policy should help Hong Kong’s data center industry grow stably long-term while keeping it profitable. It should urge data centers to adopt energy-saving technologies, which helps them cut costs and improve competitiveness. It also supports the growth of related industries and strengthens Hong Kong’s economy. Socially, the policy should examine the social impacts of data centers. For example, reducing their energy use and emissions can improve air quality and public health. Environmentally, the policy should reduce data centers' energy consumption, cutting greenhouse gas emissions and minimizing natural resource use.

6.1.5 Adaptability

Adaptability evaluates the adaptability of the alternatives in response to future uncertainties. Because data center technologies develop quickly and market demand changes, policy options need to be adaptable to future uncertainties. They should be able to change and grow flexibly as technologies and markets change. For example, the policy can set up a system to adjust energy efficiency standards dynamically, updating them regularly based on technological progress and changes in energy use. It keeps the policy effective and relevant. Facing possible future policy changes and international rules, Hong Kong's data center energy policies should also be flexible and forward-looking. It allows quick responses to external changes and ensures long-term sustainable development of data centers.

In this study, weights are assigned to each criterion to make it easier to measure and prioritize them. The weights are based on how important each criterion is for achieving sustainable development in Hong Kong's data centers. Effectiveness and efficiency each receive a weight of 0.25. It is because they are crucial for ensuring policies meet their goals. Feasibility and sustainability balance are each given a weight of 0.2. It shows their importance in ensuring policies can be realistically implemented and adapt to changes. Adaptability has a slightly lower weight of 0.1. It is because it is a more overarching goal that is supported by the other criteria.

6.2 Multi-criteria Analysis of the Policy Alternatives

6.2.1 Current Policy

The current policies of the Hong Kong data center contain building energy codes, technical guidelines, assessment and certification, and incentives for additional floor area. Specifically, on the regulatory side, Building Energy Codes (BEC) and Energy Audit Codes (EAC); on the policy scheme side, the Fresh Water-Cooling Towers Scheme; on the guidelines side, the Green Data Centers Practice Guide and Sustainable Building Design Guidelines; on the information side, BEAM Plus New Data Centres; and on the fee exemption side, Gross Floor Area Concessions.

Effectiveness: Very Low. Existing data center policies in Hong Kong have limited effectiveness in addressing market and government failures. While regulations such as the BEC and EAC set basic energy efficiency requirements, they do not specifically address the high energy consumption of data centers, and there is a policy gap. Moreover, these policies apply primarily to building energy efficiency in general, not to the energy-intensive industries specific to data centers. They have not been effective in correcting negative externalities, addressing the conflict between the profit motive and environmental benefits, and the problem of data center overcrowding.

Feasibility: *High.* The Green Data Center Practice Guide and the Sustainable Building Design Guide offer practical guidance on improving energy efficiency and environmental performance in data centers. They help operators understand and use energy-saving technologies and practices. Also, the BEAM Plus New Data Center Assessment and Certification Program provides a clear framework for evaluating and improving the sustainability of new data centers. Data center builders are more likely to accept these policies. This is because achieving higher energy efficiency and environmental standards can make their facilities more marketable.

Efficiency: *Moderate.* The government provides additional floor area incentives to encourage building operators to adopt energy-efficient technologies and measures. In addition, the voluntary Energy Efficiency Registration Scheme for Buildings (EERSB) program offers tax incentives for spending on energy-efficient buildings. This program encourages data centers to use energy-saving technologies and management methods to lower operating costs. However, there are no mandatory rules specifically for data centers. This means some operators may not want to adopt energy efficiency measures, which limits how well resources are allocated overall.

Sustainability Balance: *Moderate.* Economically, government support measures have helped the data center industry grow. Socially, policies have increased the industry's awareness of energy efficiency and environmental protection, promoting a green image. Environmentally, the Building Energy Efficiency Ordinance and related guidelines have helped reduce energy use and carbon emissions in buildings, including data centers. However, the lack of mandatory standards and not enough focus on renewable energy development limit the policy's ability to achieve a full sustainability balance.

Adaptability: *Low.* Current policies do not fully address the problem of redundant data centers when market demand changes. As the data center market keeps growing, there is already a risk of wasted resources due to oversupply. This trend is caused by things like speculative investment and too much government support for data center construction. Existing policies have no system to adjust data center supply dynamically as the market changes. This leads to inefficient resource allocation.

6.2.2 Binding PUE Standards

Binding PUE Standard policy aims to address inefficiencies in the data center energy efficiency framework by implementing a phased regulatory approach. This gives operators time to upgrade their facilities with energy-efficient IT equipment and other efficiency measures.

Effectiveness: *High.* PUE (Power Usage Effectiveness) is the most common measure of data center energy efficiency. By enforcing PUE standards, governments can effectively monitor and regulate energy consumption in data centers, ensure compliance, and push companies to adopt energy efficiency measures. This can help address ineffective energy efficiency frameworks. For example, Singapore's requirement that data centers have a PUE of ≤1.3 demonstrates the feasibility of such standards in improving energy efficiency reporting and provides a feasibility basis for implementation in Hong Kong.

Feasibility: *Very high.* The Hong Kong government needs to establish detailed standards and guidelines for PUE calculation, reporting, and verification. It must also enhance its regulatory capabilities. Singapore's Energy Efficiency Directive provides a reference with clear PUE standards and reporting requirements. Organizations can reduce PUE through technology upgrades and management optimization. While some data centers may face initial refurbishment costs, most are likely to support the policy because of its long-term benefits.

Efficiency: *Moderate.* In the short term, it guides the data center industry towards higher energy efficiency with strong enforcement. Such mandatory standards are less costly in terms of policy implementation. Although in the short term, data center operators must initially invest in energy-efficient equipment, which may seem costly. In the long run, they can cut operating costs by reducing PUE (Power Usage Effectiveness) and improving energy utilization.

Sustainability Balance: *High.* From an economic point of view, improving energy efficiency helps reduce operating costs and improve competitiveness; from a social point of view, it reduces negative impacts on the environment and meets society's expectations for sustainable development; and from an environmental point of view, it directly reduces energy consumption and carbon emissions and realizes the harmonization of the economy, society, and the environment. Adaptability: Very high.

Adaptability: *Very high.* Hong Kong can adjust the phased PUE targets according to its specific situation. This flexibility allows it to adapt to market changes and technological advances. For example, the government can revise the PUE targets according to the development of energy-efficient technologies and changes in market demand. This ensures that the policy remains effective in promoting sustainable energy consumption in data centers.

6.2.3 Transparency and Collective Governance

Transparency and collective governance policies for facility carbon budgets require shared facility operators to disclose aggregated energy consumption data from tenants through a transparent framework, such as energy consumption, energy mix, etc., and implement collective governance to optimize energy management.

Effectiveness: *Moderate*. In the short term, it guides the data center industry toward higher energy efficiency with strong enforcement. Such mandatory standards are less costly in terms of policy implementation. Although in the short term, data center operators must initially invest in energy-efficient equipment, which may seem costly. In the long run, they can cut operating costs by reducing PUE (Power Usage Effectiveness) and improving energy utilization.

Feasibility: *Low.* Data centers have advanced energy monitoring and data management technologies to collect and process tenant energy use data. However, this policy may face strong resistance from data centers. This is because they are worried about business data confidentiality and industry competition. For example, competitors might estimate operating costs from disclosed data, which could harm a company’s competitive edge.

Efficiency: *High.* The main cost of implementing this policy is the establishment of disclosure mechanisms and data reporting systems. Once these mechanisms are implemented, the policy can help data centers improve energy efficiency independently. This brings long-term economic benefits. For example, the European Union’s Energy Performance of Buildings Directive (EPBD) sets energy efficiency goals for each country. It focuses on energy efficiency and indirectly reduces greenhouse gas emissions. By cutting energy use by half compared to 2005, it plays a key role in achieving “net-zero greenhouse gas emissions by 2050.”

Sustainability Balance: *Moderate.* More transparency can encourage public scrutiny of data center energy use. It also protects the information rights of tenants, investors, and other stakeholders. But there is a risk of unequal competition in the industry. In the early stages of policy implementation, data centers may only disclose data passively without taking real energy-saving measures. To achieve full sustainability balance, policymakers need to figure out how to turn data transparency into actions that reduce carbon emissions and improve energy efficiency.

Adaptability: *High.* Transparency frameworks and indicators can fit different situations. When more advanced energy monitoring technologies become available, data centers can adopt them to make data collection more accurate and efficient. This flexibility allows the policy to adjust to market changes and technological progress. It ensures the policy remains effective in promoting sustainable energy use in data centers.

6.2.4 Tiered Subsidies

The tiered subsidy policy involves tiering data centers based on a social cost-benefit analysis of factors such as data center importance, redundancy, and energy efficiency. Differentiated energy consumption standards and subsidy policies are established for each tier.

Effectiveness: *Very high*. By categorizing data centers and providing customized subsidies, it directly targets high profit-oriented energy consumption and the conflict between profit goals and environmental benefits. The policy offers financial rewards to data centers. These incentives aim to boost energy efficiency and encourage the adoption of sustainable practices. Additionally, the policy helps governments distribute resources more effectively. It avoids a universal approach and increases the accuracy of government actions.

Feasibility: *Moderate*. Implementing this policy requires a social cost-benefit analysis (SCBA). This analysis needs cooperation across different sectors and professional evaluation. Data must be gathered from various sources and accurately measured. This ensures the fairness and reliability of the assessment results. Data should be collected from different places and measured correctly. This makes sure that the results of the assessment are fair and can be trusted. But collecting and measuring data takes a lot of resources and time. Even so, data centers will probably support the policy. The subsidies can help them pay less for running their operations and make them more competitive in the market. To make it easier to put the policy into practice, the government can simplify the process for data centers to participate. They can do this by giving clear instructions and making the application process less complicated.

Efficiency: *Moderate*. On one side, the financial rewards motivate data centers to become more energy-efficient. In the long term, this could result in substantial energy savings and cost reductions. The differentiated subsidy method also optimizes resource allocation. It channels more support to data centers that are crucial and highly energy-efficient. On the other side, the complexity of the subsidy system lessens the policy's efficiency to some degree. There are several issues to address. These include setting a reasonable subsidy amount, creating a fair and transparent application process, and ensuring timely fund distribution. For instance, data centers might face problems during the application process. This can cause delays in receiving subsidies and implementing energy-saving measures.

Sustainability Balance: *High.* In terms of the economy, the policy helps the data center industry in Hong Kong grow steadily over time. It does this by giving financial rewards to make data centers use energy better. It helps data centers save money on their operations and do better in the market. For society, the policy is good for people's well-being. It reduces air pollution and creates a healthier environment. For the environment, the policy encourages data centers to use clean energy and technologies that save energy. It cuts down on carbon emissions and helps use natural resources in a more sustainable way.

Adaptability: *Moderate.* It allows changes to the amount of subsidies and energy efficiency rules. These changes can be made as technology improves and the market changes. For example, when new energy-saving technologies come out, the government can change the subsidy amounts. This shows the new developments and encourages data centers to use these new technologies. The policy can also be changed to fit future policy updates and international rules. However, to make sure the policy can adapt well, the government needs to set up a system to watch and evaluate it. This system will let them check regularly if the policy is working. They can then make changes quickly when new problems arise or when the data center industry changes.

6.2.5 Strategic Reconfiguration of Data Center

The Data Center Strategic Restructuring Policy aims to optimize resource allocation by reusing inefficient data centers, for example, by consolidating them into community technology centers and reducing inefficient data centers.

Effectiveness: *Very high*. The policy effectively addresses market failures, i.e. the failure of the pricing mechanism to reflect environmental costs and information asymmetry, by addressing the problem of inefficient data centers wasting resources. It also enhances rationalization of resource allocation, reduces waste in inefficient data centers, and directs market resources to more efficient facilities. In addition, it provides a basis for government decision-making, avoiding a "one-size-fits-all" approach and increasing the effectiveness of government intervention. By directly reducing energy consumption and improving energy efficiency, the policy helps data centers become sustainable. For example, the U.S. Environmental Protection Agency (EPA) closed a Tier 2 data center in 2021 and used Data Center Infrastructure Management (DCIM) tools to identify and reduce underutilized servers in tiered data centers.

Feasibility: *Low*. Conducting a Social Cost Benefit Analysis (SCBA) requires cross-departmental collaboration and professional evaluation, involving data collection from multiple sources and accurate quantification to ensure fairness. Tier 3 data center operators may face outright shutdowns, resulting in significant headwinds. These operators have invested heavily in construction and operations, and a sudden policy change could result in loss of assets and operational difficulties, reducing their acceptance of the policy. In addition, competing data centers may be reluctant to merge.

Efficiency: *High*. Retooling or consolidating inefficient data centers can result in significant energy and cost savings in the long run. For example, data centers that are converted into community technology centers can utilize renewable energy microgrids, which can reduce energy costs and increase energy efficiency. In addition, community technology centers can provide a variety of local services, generating social benefits. However, in the short term, the strategy requires an upfront investment in data center transformation. For example, data centers need to install advanced cooling systems and energy management software, which can involve considerable initial costs. But these investments can be offset by long-term operational cost savings.

Sustainability Balance: *Very high*. For data centers that are tiered and upgraded to Tier 3, operating costs are reduced and energy efficiency is improved, resulting in increased competitiveness. The policy effectively reduces energy consumption and carbon emissions, supports real-time regional peak shaving and valley filling, shares and visualizes utility usage information, and prioritizes the distribution of power to elevators and evacuation centers during emergencies. From a social perspective, it plays a key role in enhancing the quality of life in the community. For example, data centers transformed into community technology centers can utilize renewable energy and advanced energy storage technologies to reduce reliance on traditional energy sources, lower carbon emissions, and minimize environmental impacts. From an economic perspective, the policy helps data centers reduce operating costs and increase competitiveness.

Adaptability: *Moderate*. SCBA assessments provide flexibility, and periodic assessments are necessary to ensure reasonable tiering. However, it takes a lot of time to transition outdated data centers due to changes in assessments. The policy can be adapted in response to technological advances and market changes, for example, by updating the transformation criteria in line with new energy-efficient technologies. This ensures that the policy remains effective in promoting sustainable energy consumption in data centers.

6.2.6 Leverage Existing Renewable Partnerships

Given Hong Kong’s limited resources, such as land scarcity and high labor costs, Hong Kong could leverage existing renewable energy cooperation policies aimed at promoting the large-scale application of renewable energy in Hong Kong’s data centers by integrating the resources and technological advantages of existing partners. For example, strengthening cross-border electricity cooperation with the Mainland by introducing photovoltaic solar energy from the Mainland and installing more solar power generation facilities in Hong Kong’s new development areas and the northern metro area.

Effectiveness: *Moderate*. This policy reduces the overall carbon footprint of data centers by integrating renewable energy into their operations at an environmental cost. It also addresses government failures by providing clear guidance on the energy transition of data centers.

Feasibility: *Moderate*. Cross-border electricity cooperation with the mainland involves different regional policies, electricity standards, and regulatory requirements. Hong Kong and the mainland need to establish an effective communication mechanism to ensure smooth power procurement. While solar and wind technologies are relatively mature, data center operators may face initial cost pressure. However, as the cost of renewable energy comes down and the market acceptance of green data centers increases, operators can gain long-term operational advantages.

Efficiency: *High*. In the long run, the costs of solar and wind power are decreasing. This happens as renewable energy technologies improve and economies of scale are achieved. Data centers that switch to renewable energy may have higher upfront costs. However, they can reduce their reliance on fossil fuels and minimize the impact of energy price fluctuations. For instance, Equinix installed a 33 kW rooftop solar panel system at its HK4 International

Business Exchange data center. Under CLP Power's Renewable Feed-in Tariff program, this system is expected to produce 33,900 kWh of renewable energy each year.

Sustainability Balance: *High*. As the cost of solar and wind power continues to fall, the data center's energy costs will be effectively controlled, improving its operational efficiency and economic benefits. At the same time, the development of the renewable energy industry will also drive the economic growth of Hong Kong locally and the Greater Bay Area. The policy is well received by the community and the public and can provide backup power for the community and enhance its energy security.

Adaptability: High. Data centers can flexibly adjust their energy procurement strategies. The use of energy storage can be flexibly adjusted to fluctuations in data center energy demand, and peak shifting and peak curtailment can be implemented across regions in real time to control power supply.

6.3 A Summary of Policy Alternatives Evaluation

The assessment against the alternative policies provides a clear direction to enhance the energy sustainability of data centers in Hong Kong. Based on the qualitative and quantitative assessment scores for each policy, and considering that there is no resource conflict between the alternative policies, this study recommends implementing regulatory standardization and compliance in the short term and advancing data center economic development and sustainable energy development in the long term. Regulatory standardization and compliance can fill in the gaps of current policies and advance data center compliance, while the other two policies require more time to develop and produce long-term benefits.

Table 2. Qualitative Alternative-Criterion Matrix

Criteria	Policy Alternatives					
	Current Policy	**Binding PUE Standards**	**Transparency and Collective Governance**	**Tiered Subsidies**	**Strategic Reconfiguration of Data Center**	**Leverage Existing Renewable Partnerships**
Effectiveness	*Very Low*	*High*	*Moderate*	*Very High*	*Very High*	*Moderate*
Feasibility	*High*	*Very High*	*Low*	*Moderate*	*Low*	*Moderate*
Efficiency	*Moderate*	*Moderate*	*High*	*Moderate*	*High*	*High*
Sustainability Balance	*Moderate*	*High*	*Moderate*	*High*	*Very High*	*High*
Adaptability	*Low*	*Very High*	*High*	*Moderate*	*Moderate*	*High*

Table3. Quantitative Alternative-Criterion Matrix

	Current Policy	**Binding PUE Standards**	**Transparency and Collective Governance**	**Tiered Subsidies**	**Strategic Reconfiguration of Data Center**	**Leverage Existing Renewable Partnerships**
Effectiveness	Rating:1 Weight: 0.25 **Total: 0.25**	Rating:4 Weight: 0.25 **Total: 1**	Rating:3 Weight:0.25 **Total: 0.75**	Rating:5 Weight:0.25 **Total: 1.25**	Rating:5 Weight:0.25 **Total: 1.25**	Rating:3 Weight:0.25 **Total: 0.75**
Feasibility	Rating:4 Weight: 0.25 **Total: 1**	Rating:5 Weight: 0.25 **Total: 1.25**	Rating:2 Weight:0.25 **Total: 0.5**	Rating:3 Weight:0.25 **Total: 0.75**	Rating:2 Weight:0.25 **Total: 0.5**	Rating:3 Weight:0.25 **Total: 0.75**
Efficiency	Rating:3 Weight:0.2 **Total: 0.6**	Rating:3 Weight:0.2 **Total: 0.6**	Rating:4 Weight:0.2 **Total: 0.8**	Rating:3 Weight:0.2 **Total: 0.6**	Rating:4 Weight:0.2 **Total: 0.8**	Rating:4 Weight:0.2 **Total: 0.8**
Sustainability Balance	Rating:3 Weight:0.2 **Total: 0.6**	Rating:4 Weight:0.2 **Total: 0.8**	Rating:3 Weight:0.2 **Total: 0.6**	Rating:4 Weight:0.2 **Total: 0.8**	Rating:5 Weight:0.2 **Total: 1**	Rating:4 Weight:0.2 **Total: 0.8**
Adaptability	Rating:2 Weight:0.1 **Total: 0.2**	Rating:5 Weight:0.1 **Total: 0.5**	Rating:4 Weight:0.1 **Total: 0.4**	Rating:3 Weight:0.1 **Total: 0.3**	Rating:3 Weight:0.1 **Total: 0.3**	Rating:4 Weight:0.1 Total: 0.4
Total Score	**2.65**	**4.15**	**3.05**	**3.7**	**3.85**	**3.5**

7 **Policy Recommendation**

The exponential growth of data centers has precipitated significant energy consumption and environmental challenges. Based on the insights gathered from the literature review and interviews, we have developed a structured set of policy recommendations for both short-term and long-term actions. These actions emphasize addressing inefficiencies, reducing energy consumption, and aligning data center operations with long-term sustainable growth and innovation.

Short-Term Recommendations (0–10 Years)

Regulatory Standardization and Compliance

The immediate policy focus centers on enhancing regulatory standardization and transparency to mitigate government failures and bridge regulatory gaps. Thus, mandating Power Usage Effectiveness (PUE) reporting for all data centers is the cornerstone step, with the target of an interim PUE of ≤1.5 by 2032. There are two key steps for implementation. First, legislatively, the Environment and Ecology Bureau (EEB) should develop a Data Center Energy Efficiency Ordinance mandating annual PUE reporting. To operationalize this mandate, a centralized PUE Reporting Portal will be established under the oversight of the Electrical and Mechanical Services Department (EMSD). This platform ensures transparent data submission while providing technical guidance, such as airflow optimization and server virtualization strategies, to assist facilities in meeting targets.

Energy Consumption Monitoring for Co-location Data Centers

Parallel to regulatory standardization, to address the challenges of energy efficiency monitoring in Hong Kong’s colocation data centers, we propose a 10-year phased policy. Our goal is to achieve energy transparency monitoring to reduce sectoral energy consumption by

30% in all colocation data centers by 2035, aligning with Hong Kong's 2050 carbon neutrality targets.

Operators will need to report aggregated data like total PUE and cooling efficiency via the Reporting Portal we discussed earlier, quarterly. We understand the importance of confidentiality; only facility-level metrics will be shared, and tenant-specific data will remain confidential. A phased implementation approach is outlined: pilot projects in Tseung Kwan O (2025–2027) will test aggregated reporting mechanisms, followed by mandatory enforcement (2028–2030) and full compliance by 2035. Collectively, these measures aim to reduce sectoral energy consumption by 30% through enhanced transparency and accountability.

Long-Term Recommendations (15+ Years)

Long-term strategies are visionary yet crucial to address the root cause of the issues — oversupply and land-energy conflicts. A three-step reconfiguration plan is proposed:

Step 1: Temporary Moratorium and Tiered Classification

There are 13 new projects planned for the coming years. A temporary halt on new data center approvals will precede a comprehensive assessment of existing facilities through a tiered classification system, informed by economic, environmental, and social metrics. Tier 1 includes high-energy commercial operators (e.g., hyperscale cloud providers) critical to economic infrastructure, such as stock exchange hubs or government cloud services. Tier 2 encompasses redundant facilities with low utilization (e.g., underused collocation hubs), while Tier 3 consists of low-utilization centers with a <60% capacity rate for consolidation. Metrics such as revenue generation, carbon footprint, and community impact will inform classification decisions.

Step 2. Development of Green Data Zones and Consolidation Incentives

Coastal areas with renewable energy potential, such as Southern Lantau, will be prioritized for “Green Data Zones.” These zones leverage natural cooling (e.g., seawater) and proximity to offshore wind farms, capitalizing on an estimated 11,280 TWh renewable energy capacity. Fiscal incentives, including 20–30% land premium reductions, will encourage Tier 1 and 2 operators to relocate to these zones. Concurrently, Tier 3 facilities will undergo phased consolidation: 20% decommissioning via mergers or repurposing (2025–2030) and a 40% reduction in total data center count by 2040. Decommissioned urban sites will be transformed into solar-powered co-working spaces, aligning land reuse with sustainability objectives.

Step 3. Renewable Energy Integration via Stakeholder Collaboration

As data centers relocate to designated zones, we propose to pursue maximum Renewable Optimization through collaboration by forming public-private partnerships (PPPs) with energy providers like CLP Holdings and China Southern Grid, focusing on grid upgrades for renewable integration. We can also collaborate with the industry-academia task force on local renewable projects on solar, wind, and water to co-design roadmaps. Instead of a full transition to renewables, we propose a more feasible Conditional Renewables integration, adopting renewables only where it’s safe and cost-effective. For example, rooftop solar and off-shore wind procurement for facilities. We are aware it’s important to avoid blanket renewable targets because they need to align adoption with Hong Kong’s grid readiness and regional partnerships like Guangdong PPAs.

8 Conclusion and Future Directions

Hong Kong’s data center industry, while a cornerstone of its digital economy and smart city ambitions, faces pressing challenges that demand a harmonized policy response. The sector’s rapid growth has exacerbated energy consumption. We drew lessons from Singapore and interviews on the value of context-specific solutions and proposed a policy framework that addresses these challenges through a dual approach: short-term regulatory measures and long-term structural reforms.

Looking ahead, Hong Kong must prioritize AI-driven energy management systems to optimize real-time efficiency. Collaboration with academia and industry to pilot liquid-cooling technologies and distributed resiliency models can further mitigate energy waste. What does all this mean for Stakeholders? The government should strengthen the regulatory framework; business needs to invest in retrofits and collaborative governance. The public should support green zoning to balance urban and community needs. Finally, growth vs sustainability is always a nuanced question worth discussing. But Hong Kong’s data centers must evolve from energy liabilities to innovation hubs, where sustainability drives competitiveness in the digital age.

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Attachment1：Interview with China State Construction Engineering (Hong Kong) Limited

Q: What are the directions for energy-saving retrofitting in your current projects?

A: One is the updating of old equipment and the other is the embedding of smart systems, such as the use of IoT platforms to achieve the scenario of lights turning off when people leave. In my opinion, the embedding of AI technology in building mechanical and electrical engineering is still in its infancy, and its actual effectiveness is limited. Currently, the application of AI in the construction field is still in the stage of language interaction models and has not yet reached the stage where AI can set energy-saving targets for systems through computing power. Many operating owners will propose visions of AI and smart control in the early stages of project promotion, but the timeline for implementation is generally extended to 5-10 years.

Q: Will the embedding of AI technology in building operation and maintenance further increase electricity and energy consumption?

A: I think there’s no need to worry. The combination of AI and buildings definitely won’t involve deploying a separate computing center for each building to handle smart operation and maintenance. Instead, it will be cloud-based and platform-oriented, serving multiple buildings and different regions. Although the energy consumption is significant, the energy-saving effects achieved through current technological means are at least 30%. If a single building has an annual electricity bill of hundreds of thousands, deploying AI separately might not be cost-effective. However, if it’s centralized and cloud-based, the saved energy costs will definitely cover the computing power consumption. It’s just that it’s still in the implementation stage.

Q: Under the energy-saving goal, are there any new technological application directions for specific mechanical and electrical systems?

A: Take the cooling system with high energy consumption in DC as an example. Since its inception hundreds of years ago, its basic operating principles have hardly undergone any revolutionary changes. In commercial settings, the most traditional heat pumps are still widely used. Its energy-saving retrofit mainly focuses on replacing aging facilities. In Hong Kong, a large part of the cost comes from labor. For instance, labor costs on the mainland are only half of the equipment cost, while in Hong Kong, labor costs can be three to four times the equipment cost. In this context, the energy performance contracting model is relatively effective. In short, our party funds the initial investment, and later, the building owner shares the savings achieved. This model is currently effective on the mainland, but in Hong Kong, owners of buildings worth tens of billions rarely lack tens of millions for replacement costs. However, we are still working in this direction because one day the owner may face funding shortages, and this can also increase our cash flow and profit margins as a contractor.

Q: In a previous interview, a view was mentioned that achieving energy-saving goals through technological upgrades is unfeasible and that it’s necessary to balance economic and sustainable factors, such as shutting down inefficient DCs and only retaining a small part of them. What’s your opinion on this?

A: This proposal is idealistic. Operators are in competition with each other. For example, the three major mainland operators all have businesses in Hong Kong with different focuses. This idea is difficult to realize in the short term.

Q: What challenges do you think will be faced in promoting energy efficiency measures among data center operators?

A: On the one hand, DC operators are not very concerned about power consumption. They require a stable power supply 24/7. Except for a small part of the office area, once the technical system causes a collapse of mechanical and electrical engineering, the consequences would be disastrous, which is of a different nature and severity compared to the shutdown of mechanical and electrical systems in office buildings. As DC operators, they are more willing to sacrifice energy consumption to ensure stability. On the other hand, there are currently no industry standards to promote energy-saving, such as PUE target. They can meet ESG goals in other ways, such as planting trees in Africa.

Q: Where do you think the main energy - saving chances for data centers are?

A: The main energy - saving chance for data centers (Energy Management Opportunity, EMO) lies in the cold air system. Electrical systems have limited energy - saving potential. They just supply stable power. If a device is plugged in, it gets electricity; if not, the power cuts off, with no extra saving potential. But cooling systems are different. They can be optimized for energy - saving in many ways. For example, smart lighting systems and smart switches can cut energy use. Also, using seawater for cooling is another way. In Hong Kong’s Kai Tak region, a study used the temperature difference in seawater to exchange heat, lowering the cooling system’s energy use.

Q: What are some ideas for energy - saving make - over of data centers’ cooling systems?

A: One idea is to cool with seawater. In Hong Kong's Kai Takregion, a study used the temperature difference in seawater to exchange heat, lowering cooling - system energy use. Another idea is liquid - cooling technology, which cools more efficiently but needs safety thought. Also, using in - cabinet cooling systems and upping cooling efficiency can help. For example, the Tseung Kwan O region used a similar method, taking the temperature difference between upper and lower water layers to exchange heat and take the building's heat away. But this might raise seawater temperature and affect Victoria Harbour's water temperature.

Q: What's the role of data - center operators in energy - saving make - overs?

A: Data - center operators hold actual operation data, which is key for energy - saving plans. For instance, such data can show equipment redundancy and start - stop times, which are important for targeted energy - saving steps. But operators' data is often not easily shared, which challenges energy - saving plan - making. As mentioned in the interview, operators may not publicize energy - saving steps not on their websites, making it hard for energy - saving teams to get key data.

Q: How does server design in data centers affect energy consumption?

A: Servers are designed for long - term stable operation. Usually, they're set for a 100, 000 - hour lifespan, with only about 100 start - stop cycles considered. So, servers aren't fit for frequent starts and stops. They're better suited for non - stop long - term operation. This design directly impacts energy use as servers can't save energy by frequent short - term starts and stops. For example, some people in the mainland buy server hardware for home use. But as servers are designed for long - term stable operation, frequent starts and stops at home can damage the hardware. This design difference makes energy - saving challenging for data - center servers.

Q: What general suggestions do you have for data - center energy - saving make - overs?

A: For data - center energy - saving make - overs, self - control logic algorithms or AI can be used to optimize energy use. For example, smart control logic can automatically shut down some idle equipment to cut energy consumption. Also, low - power operation modes can be explored, considering server hot and cold backup issues. Energy can be saved by optimizing backup strategies. As mentioned in the interview, large - enterprise servers have a long design life and few start - stop cycles, so low - power operation modes can reduce energy use. At the same time, operators can optimize equipment operation via embedded software or self - control logic to save energy.

Q: What policies or plans by the Hong Kong government regarding data - center energy - saving do you know of?

A: The Hong Kong government has been mulling over the environmental problem of refrigerants since last May and has kicked off relevant studies. As per the Montreal Protocol, Hong Kong is set to gradually swap out traditional refrigerants like the 134A type for more eco - friendly alternatives. Even though this switch might lead to a rise in equipment costs, it’s a necessary step to meet environmental standards. In addition, Hong Kong is also exploring the potential of photovoltaic and energy - storage technologies to ensure the sustainable use of energy resources. For instance, the integration of photovoltaic systems into building designs, both on facades and rooftops (BIPV and BAV technologies), shows great potential in boosting the utilization of renewable energy. Meanwhile, energy - storage technology is emerging as a promising energy - saving solution. Take the 42 - foot energy storage cabinet at Hong Kong’s airport as an example; it can supply power during emergencies and play a role in peak - shaving and valley - filling operations.

Attachment2：Interview with Lan

Q: So, well, actually, we’re subsequently about, like I said, three biggest parts. One is what do you think is like the currently, like what is the biggest challenges in data centers in terms of energy consumptions.

A: I would say the biggest challenge in Hong Kong is the lack of intrinsic environmental compliance driving energy efficiency. Unlike regions such as California, where regulations mandate strict PUE (Power Usage Effectiveness) targets, for example, achieving a specific PUE by 2027), Hong Kong lacks enforceable thresholds. PUE measures total facility energy divided by IT equipment energy, with 1.0 being ideal. Historically, innovation in data centers has been propelled by external mandates—not organic industry priorities.

In Hong Kong, environmental concerns remain secondary because energy efficiency isn’t perceived as competitively advantageous. The industry focuses on performance, for example, data speed, hardware capabilities, rather than energy proportionality—how much energy a task consumes relative to its output. For example, telecom sectors prioritize rapid data transmission over optimizing energy per task. Without regulatory pressure or internal cost incentives, operators lack motivation to prioritize sustainability. Thus, the root issue is environmental targets not being embedded into the data center industry’s operational or financial framework.

Q: So, for example, for PUE, which organizations are responsible for making?

A: So, for example, in Europe, there’s a new legislation, it’s a 2023,2020, three Energy efficiencies, which establishes a target decision. Any new data center project anywhere in

Europe, they need to comply because it's a law. It's a European law and then the countries speak their own law. Like European Union defines and then everyone is going to have to call. So, for example, in Germany, it is already a law. So, if I have a leadership in Germany, it needs to comply. So that's the, I'd say the biggest issue two here is these.

You know, return on investment, ROI? So environmental source and have ROI in the tech industry, in this case, telecommunication sector, data centuries. So, in general, they don't consider by themselves. Talking about reappear industry, they're not going to look unless someone. I'd say, I think that's the biggest issue here. Environmental sources do not enter in the tech agenda unless it is imposed to back each other and then they must comply with it. So, I'd say that's the number zero.

Q: Without this agenda, so basically there's no like specific like aspect or skill that like there's, for example, the current emission level or like, yeah, so that issues cannot be contained or followed by that logic. We'll focus like the consequence of that

A: The consequence of that is, let's say Hong Kong is gonna be more and more data centers. For example, the biggest, I cannot tell which building, but there is a particular building, TKO, which is the data center, which is the highest energy consuming beauty in the whole home. That there's one particular building there which consumes more energy than like two labels. So, the problem we gonna have, if this is not a checklist, we're gonna put more data center, more and more energy until one point we're gonna have a massive one right here in the electricity warehouse. I'm gonna must put it down. It's just like, let's say is that is essentially any shop supplier demand. It puts more datasets gonna license, gonna have more and more demand. It will reach a point where, you know, if your capacity of supplies does not follow the same growth rate of the capacity of like mature demand. So gonna have a straight and then the local government is gonna have to step in and. It holds a cap consumption, and this cap and consumption would generally go back to what I mentioned, the PUE, probably a PUE targets.

I think the latest example for you is Singapore happy growth search Singapore. So essentially what Singapore made it right the limitation in 2,019. And then in 2022, they made a new license. I would say, but essentially what happens in Singapore is the future of Hong Kong. Cuz in Singapore, they hold a limitation because of electricity problems. And then they try to freeze any new permits. And then 2022, during the previous, it’s not saying how come a proud follower, simply

Q: Which aspect it’s the biggest one is electronics consumption?

A: It depends because it is a lot if you are in a in electric spirit. So when you are connected to a electricity network, which has a lot to renewables. So there are two renewables. It’s a problem because they’re gonna have a lot of emissions. But let’s say to have a lot of renewables, no problem. In Hong Kong it makes a problem. So you can put that down because, so data centers in Hong Kong, they’re in TKO and some industrial state help me. So which means that they need to be necessarily connected to CLP. You cannot be Hong Kong collection, can only be CLP. So, there’s a connection that goes to mainland. So China Southern Bridge, CSG, and that’s any data set for here.

Why it’s a problem here? Because you have this connection and because I have this connection, CLP comes to you if you’re in center and you say we don’t have actually renewables, we're just buying from Chinese Mainland. So we're not gonna actually put renewables on your data center because it's too expensive to buy new land here to build a renewal farm away. So, you know, with CLP, we control the electricity run by all renewals from mainly Chinese one renewal country. So this is a problem more related to emissions is that it's very difficult for you to build renewables in Hong Kong. Like it's very like economically doesn't make sense. So in general, it's realistic to assume that there won't be capacity. the missions become a problem because there won't be capacity here to have renewables to fulfill the data sets. Most of the energy data sets are gonna use here in Hong Kong could not renewably base because you cannot produce cosine because some people control. So essentially it will be a problem because you have a lot of electricity, you can have a lot of emissions, in HK.

But that's why I say it's important. I think that you really stress that it's important because not every place is gonna have this problem for emissions in HK.

Q: Were there any limitations in the availability or quality of data, and how did you address them?

A: It is difficult to obtain data. It kind of depends on the market in Hong Kong. In the U.S., ICT companies protect their data using confidentiality laws, citing competitive positioning. Hong Kong follows similar practices. The most common form of data center is what we call a colocation data center. A colocation data center is a very big telecommunication company which builds the data center and arranges the data center space to the minor companies such as the startups and cloud service. Because the data of these companies cannot be obtained by paid and law. So there’s a need to push for disclosure of data and collaborative governance. In the shared business model, the tenants of the data center, the customers, report to the data center in different reports, and then the data center reports to the public. A more collaborative model in which many companies join together to build a telecom building is very popular, with data center guides and software providers.

Q: What are the main challenges for data center sustainability in Hong Kong?

A: The first problem is that cooling is a challenge for cooling data centers effectively due to the tropical climate. Governments need to develop some sort of roadmap to assess which route they should take to address cooling data centers. For example, Microsoft builds its data centers underwater for cooling, and Singapore’s liquid cooling technology is very effective at cooling. Water cooling is not only a waste of water but also faces problems such as water pollution, so strategies are needed to address this. The second problem is that the high land prices make construction expensive, necessitating government planning and incentives. High land prices lead to very high capital expenditure and operating costs. If Hong Kong wants more data centers, it needs to ensure that there is enough space, such as industrial areas or other places where data centers need to be placed.

Q: What is the potential of AI technology in integrating data centers and reducing energy consumption in data centers?

A: The impact of AI on energy consumption in data centers is inconclusive and complex. It depends on various factors.

Q: What policy recommendations do you suggest for sustainable energy use in data centers?

A: Policies should focus on energy efficiency, push to disclosure of basic data and information such as energy efficiency; set targets for metrics like PUE, for example, establish a certain threshold of PUE reaching 1.2 by 2028 and force them to do that; promote renewable energy use, for example, the companies need to have access to electricity or buying electric certificates; collaborate with the partners like CLP and promote stakeholder engagement; adopt technical data center cooling techniques, such as carefully considering building data centers like Microsoft's underwater; and proper zoning are crucial, for example, data centers should be built in the industry part cuz this is economically feasible. So probably the government needs to plan well where they're gonna put these new zoning areas.

Attachment3：Interview with Elvis Au

Q: Thank you for joining us today. Our project investigates energy consumption challenges in Hong Kong’s data centers, with the goal of proposing policy solutions. We understand you’ve worked extensively in sustainability—could you share your perspective on the key issues and potential pathways forward?

A: Absolutely. Before diving in, let’s clarify your scope: Are you focusing solely on technical solutions (e.g., energy efficiency), or are you considering broader systemic factors like economic incentives or regulatory gaps?

Q: Initially, we focused on technical fixes—improving cooling systems, adopting renewables like solar, or retrofitting older facilities. But we’ve hit roadblocks. For instance, data center operators are reluctant to share energy consumption data, citing confidentiality. Hong Kong also lacks clear regulations or targets for this sector.

A: Technical solutions are important, but they’re only part of the puzzle. Where are you in your analysis? Have you identified the root causes of high energy consumption, or are you still mapping symptoms?

Q: We’ve identified cooling inefficiencies due to Hong Kong’s humid climate and the lack of renewable energy infrastructure. For example, many centers rely on traditional air conditioning, which consumes 30-40% of their total energy. But without access to operational data, it’s hard to quantify the scale or prioritize interventions.

A: Let’s step back. What theoretical framework guides your analysis? Are you using energy economics, sustainability models, or policy evaluation frameworks?

Q: We've framed it as an energy optimization problem. For instance, one proposal is mandating rooftop solar panels or incentivizing water-cooling systems. But we're open to refining our approach.

A: That's a narrow lens. Framing dictates solutions. If you label this an "energy problem," you'll default to efficiency tweaks. But what if it's an economic problem? For instance, why are data centers concentrated in Hong Kong, a city with limited land and renewables, instead of regions with abundant wind or solar resources?

Q: We hadn't considered that angle. How would reframing it as an economic issue change our analysis?

A:You'd ask harder questions-Location rationale: Why build energy-intensive facilities in a dense urban area with high electricity costs and low renewables? Could they operate offshore near wind farms or in solar-rich regions, transferring data via undersea cables?

Societal value: Do these centers generate enough economic or social benefit (e.g., jobs, digital infrastructure) to justify their environmental costs?

Q: But couldn't data centers offset their footprint? For example, AI hosted here might optimize logistics or energy grids globally, reducing emissions elsewhere.

A: A valid point, but you must quantify that offset. Hong Kong's grid is 70% fossil-fueled—hosting energy-hungry AI here might still be net-negative. Compare this to Norway, where data centers run on hydropower. If the societal benefit is marginal, policymakers should ask: Why not relocate?

Q: Hong Kong already has hundreds of data centers. Are they all essential?

A: A question policymakers rarely ask! Many exist because of historical investments or tax incentives, not societal need. Conduct a social cost-benefit analysis:

- Economic benefits: Jobs, revenue, digital connectivity.
- Environmental costs: Emissions, land use, strain on the grid.
- Alternatives: Could cloud services be sourced from greener regions without sacrificing performance?

If costs outweigh benefits, recommend scaling down. For example, Singapore limits data center growth to align with sustainability goals.

Q: How would this translate into actionable policies?

A: Three pillars:

- Location-based incentives: Subsidize data centers built near renewable hubs (e.g., offshore wind farms in Guangdong) or mandate “green leases” for land use.
- Efficiency mandates: Require water-cooling systems, waste heat recycling, or onsite renewables (e.g., solar curtain walls).
- Transparency regulations: Force operators to disclose energy use, PUE (Power Usage Effectiveness), and carbon footprints. This also addresses your data access issue.

Q: What’s the biggest blind spot in current approaches to this issue?

A: Solving symptoms, not systems. For decades, we’ve optimized tailpipe emissions without questioning car dependency. Similarly, chasing incremental efficiency gains in data centers ignores the root issue: Do we need this many? Einstein said, “We cannot solve problems with the same thinking that created them.” Shift from “How do we make data centers greener?” to “Why do they exist in this form?”

Q: Any final recommendations for our policy framework?

A: Three priorities:

- Reframe the narrative: Position data centers as part of Hong Kong’s sustainability strategy, not just tech infrastructure.
- Cross-border collaboration: Partner with Guangdong or Southeast Asia to build renewable-powered data hubs, sharing energy and bandwidth.
- Demand-side policies: Tax energy-intensive centers or offer rebates for downsizing/relocating.

Q: This reframing is transformative—we’ll integrate these strategies into our analysis. Thank you for the depth and clarity!

A: My pleasure. Remember: Policy isn’t just about fixing what’s broken. It’s about envisioning what could be.