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Interim Report: Green FinTech and Data Centres in Singapore

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Executive Summary

The global demand for data centres (DCs) has been increasing rapidly with the growing use of Internet services and cloud storage. Singapore is a key DC hub in Southeast Asia, attracting significant investments and supporting the city-state's digital economy. However, concerns about energy consumption and carbon emissions led to a moratorium on new DC construction in 2019, which was lifted in 2022 with new environmental requirements.

This report presents interim findings from a research study on the future of green fintech and data centres in Singapore. Taking an interdisciplinary approach, we examine the economic, environmental, and regulatory dimensions of sustainable DC futures in Singapore, with the view of identifying transferable lessons to the rest of Southeast Asia and other tropical geographies. We identify four complementary factors that contribute to Singapore's current DC hub status in Asia Pacific: mature infrastructural network; trusted regulatory environment and political stability; physical environment free from natural disasters; and agglomeration effect of DC operators and related industry actors in attracting skilled works and international corporations into Singapore's DC ecosystem.

However, with the prospect of higher costs and increasing regulatory restrictions on constructing new DCs, there is an emerging trend of DC projects and services shifting to neighbouring countries. Singapore's data overflow points to three possible development trajectories: spillover markets (into Johor Bahru and Batam); development of sovereign neutral zones (akin to a freeport) with data securely stored off Singaporean shores; and decentralised model of growing DC capacities in the Southeast Asia region instead of a concentrated DC hub. However, emerging DC markets in the region face challenges such as lack of infrastructure, shortage of skilled labour, and uncertain political, regulatory and legal environments.

The study highlights unique decarbonisation and sustainability challenges faced by tropical DCs in densely built-up areas. Key barriers include: the absence of free air cooling; over-reliance on Power Usage Efficiency (PUE) as a sustainability indicator; inadequate attention to water efficiency; lack of viable renewables; the highly risk-averse culture in the DC sector; and risk of greenwashing for green financing solutions. Navigating sustainable pathways for Singapore's DC sector presents environmental, economic and technical challenges that will require collaboration between experts and policy-makers in digital, environmental, energy and infrastructure, and financial sectors. Developing a skilled multi-sectoral DC labour market and establishing an industry association could be important in securing a sustainable future for the DC sector in Singapore.

1. Introduction

The global demand for data centres (DCs) has skyrocketed in the last decade due to the increasing demand for internet services and cloud storage. Our current digital lifestyle relies heavily on DCs, such as browsing social media sites and streaming services, storing documents on the cloud, using online banking, and accessing government services. The recent emergence of generative artificial intelligence has further amplified the demand. Estimates of DC sector market valuation vary but all unequivocally indicate an upward, exponential trend. According to JLL's Data Centers 2023 global outlook, the colocation sector is projected to experience a compound annual growth rate (CAGR) of 11.3% between 2021 to 2026, whereas the hyper scalers are expected to experience an even higher CAGR of 20% (See Appendix A for definitions of different DC categories) (JLL 2023). The market is valued at USD 50 billion in 2021 and is projected to reach USD 120 billion by 2030 (Spherical Insights and Research 2023).

Although DCs operate behind the scenes and often under the radar, they constitute critical infrastructures in supporting the burgeoning digital ecosystem. Their rapid growth has caught the attention of investors, governments and regulators, and environmentalists. For investors, DCs are a highly desirable asset class with stable cash flow and a promising growth trajectory. For governments and regulators, DC infrastructures present opportunities for creating a competitive edge in the rapidly growing digital economy, but they also create new challenges for governing data trust, risks, and security (Department of Digital, Culture, Media and Sport 2022). Additionally, unchecked expansion of DCs leads to dramatic surges in energy consumption, draining the grid and compromising governmental climate and environmental commitments at the same time (IEA 2022).

In Singapore, DCs play an integral role in supporting the city-state's status as the internet and connectivity hub of Southeast Asia. Over the past decade, the government has actively promoted the development of FinTech, which attracted an influx of more than a thousand start-ups and USD 4.1 billion worth of investments in digital payment, digital assets, lending and financing platforms, and regulatory technology in 2022 alone (KPMG 2022). At the same time, Singapore's DC sector has grown exponentially in the last decades. Estimates vary, but analysts generally point to the rapid growth in size and prestige of Singapore's DC market, with Arizton estimating the sector to be worth USD 4.3 billion in 2021, whilst Cushman and Wakefield's latest report ranks Singapore as the world's third most important DC hub in 2023.

However, this promising trajectory was halted when the government implemented a moratorium in 2019 that banned the building of new DCs, citing energy consumption and carbon emissions concerns (Data Centre Magazine 2020). The moratorium was lifted in 2022 but new building requirements and limits were put in place to manage the environmental impacts of the sector (IMDA 2022). DC industry stakeholders fear the erosion of Singapore's competitiveness, especially compared to neighbouring countries where the availability of cheaper land and energy appeals to the overflowing DC demands in Singapore. Furthermore, the shortage of DC services may curtail other sectors reliant on digital applications and services, including Singapore's growing FinTech sector. At the same time, the new

requirements to align DC capacity growth with climate commitments could serve as a catalyst for innovation and collaboration.

This report presents interim findings from an interdisciplinary research study that investigates the future development trajectory of Singapore's DC sector, focusing on economic, environmental and regulatory dimensions of sustainable DCs development (see Figure 1). Research data are based on (I) desk-based research of DC assets in Singapore, which includes analysis of documents and reports from government and regulatory agencies, financial, technology and DC corporations, consultancy firms, industry organisations, third sector, and media coverage; (II) semi-structured interviews with 31 industry stakeholders; (III) group discussions at a stakeholder workshop (with 60 participants) held in April 2023 in Singapore.

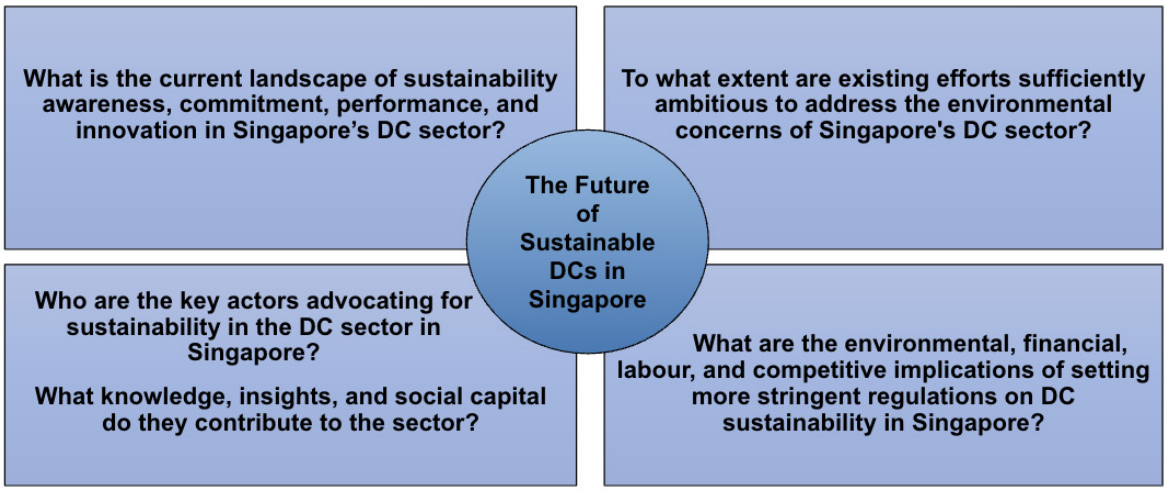

Fig. 1 Research questions for the study

Our research aims to improve the existing understanding of financial and energy production networks to account for the disruptions and new configurations emerging from digitalisation and decarbonisation. In doing so, we aim to bridge the gap between the ever-expanding *virtual* spaces of the cloud and digital platforms with their often overlooked *material* environmental footprints. Additionally, we aim to deepen knowledge of the regional economy of Southeast Asia, as countries compete or collaborate to enhance their economic competitiveness whilst securing a sustainable future. Our research findings will highlight viable pathways and future scenarios for the growing DC sector, with particular relevance for both industry and policy stakeholders.

2. DCs and Singapore's digital economy: Infrastructure, Investments, and Employment

The evolution of the DC in Singapore can be categorised into the three key functions of DCs: storage, network, and computing (Lykou *et al.* 2018). The first DCs in Singapore emerged in the 1990s, when Temasek-owned corporations, such as Keppel, responded to the demand

for efficient, onshore, and secure data storage from banks located in the central business district. As the demand for digital data storage services increased, colocation operators such as Equinix entered the Singapore market throughout the early 2000s, bringing new investments to build large-scale colocation centres. The rise of cloud services on a global scale in the mid-2010s further propelled the growth of Singapore's data industry. The country's robust demand for data services, coupled with its reliable connectivity and energy infrastructure, made it an obvious choice for American BigTech firms such as Amazon, Microsoft, and Google, as well as Chinese players, such as Huawei and ByteDance, to establish their Southeast Asian presence in Singapore. Singapore's well-established network of sub-sea cables, stable energy grid, and the presence of a strong digital ecosystem paved the way for its status as Southeast Asia's DC hub.

As of 2021, Singapore is home to 93 DCs, supporting more than 1000 MW worth of supply, making it Asia Pacific's leading DC hub despite its limited land size (AlphaBeta 2022; JLL 2023). Singapore receives just over half of investments channelled towards DCs in Southeast Asia (Arizton 2022). AlphaBeta (2022) estimates that direct investment in DCs amounted to SGD 1.07 Billion in 2020, while indirect and induced investment combined totalled SGD 1.3 Billion.

The substantial DC investment flows point to the sector's economic importance. Some critics caution that the sector brings very limited direct employment to the country, which is disproportionate to the energy, water, and land that the DC sector demands. Indeed, DCs only generate 7000 direct employment opportunities in Singapore (AlphaBeta 2022). That being said, the upstream DC supply chain creates an additional 17000 jobs, and low-latency cloud service enabled by DCs supports approximately 1.2 million jobs (ibid). The DC sector arguably creates significant employment and economic growth opportunities both directly and indirectly. The moratorium, however, could deter future investments in Singapore's DC with negative implications for job creation and future economic growth.

3. Does going digital mean going green?

3.1 Environmental impacts of DCs

The economic dimension (e.g. investment and employment) represents only one facet of the strategic concerns facing the DC sector. Singapore must also account for the implications of the DC sector on its climate commitments as specified by the Singapore Green Plan 2030. "Going digital" is often associated with "going green", with DCs enabling sustainable transformation in three key ways:

1. DCs' mass storage capacity enables the deployment of big data and Internet of Things (IoT) technologies, which allow companies to monitor and identify operational inefficiencies across their value chains more effectively.
2. DCs are the physical infrastructural basis for deploying artificial intelligence (AI) solutions. With AI, companies can automate data-driven and predictive analysis, including assessments of energy consumption, carbon emissions, and other

environmental impacts. This automation enables faster and more accurate decision-making processes, leading to improved efficiency and sustainability.

3. DCs support cloud computing, which provides a centralised platform for seamless data sharing and collaboration across multiple stakeholders within a company's value chain. By utilising the cloud, organisations can establish standardised procedures and practices throughout their operations, promoting efficiency and sustainability on a broader scale.

However, digital infrastructure and operations also carry a substantial environmental footprint. Notably, IEA (2022) estimates global DCs and data transmission services make up 1% of energy-related greenhouse gas emissions. As the Covid-19 pandemic has irreversibly driven both professional and social lives online, with increasing demand for connectivity, storage, and computing, the entire information technology sector is expected to accelerate in the 2020s to account for 21% of projected global energy demand—of which, DCs electricity use will likely increase about 15-fold by 2030, to 8% of projected global energy demand (Jones *et al.* 2018). However, it is challenging to trace carbon emissions across the entire production and supply chain of digital equipment and DCs, which disincentivises accurate, timely, and reliable carbon disclosures of digital carbon footprints (Gupta *et al.* 2021; Stonham 2022). This transparency and accountability challenge is compounded by the fact that for most corporations, DC use is often outsourced to a cloud or colocation provider, which falls under Scope 3 emissions[1]. Incidentally, the disclosure rate of Scope 3 emissions is also the lowest (Hettler and Graf-Vlachy 2023).

Unlike other 'hard to abate' sectors (e.g. oil and automotive industries), the environmental footprint of DCs has largely remained under the radar of regulators and civil society until recently. That being said, there are emergent environmental initiatives from the DC sector. Notably, the Climate Neutral Data Centre Pledge boasts more than 100 DC operator and trade association signatories, committing to 100% carbon-free energy, responsible water consumption, energy efficiency, heat recycling, and reusing and repairing servers.

3.2 Unique challenges of tropical DCs

The tropical climate of Singapore poses unique challenges to efficient DC operations. The year-round warm temperatures preclude certain operational efficiency measures typical in temperate climates, such as ambient cooling during winter. Thus, DCs traditionally rely heavily on cooling via air conditioning in Singapore, which significantly increases the power usage efficiency (PUE) of the sector. Relative to other small sectors, DCs in Singapore take up a disproportionately large share of (~7%) of national energy supplies. More recently, liquid cooling has been introduced as an alternative cooling strategy (see Section 4.3), however, this poses additional hurdles in Singapore's water-scarce context. Additionally, the humid conditions also reduce the lifespan of digital equipment. Finally, it is worth noting that Singapore is a highly land-scarce country, meaning DCs will constantly be competing for land

[1] The concept of three scopes of carbon emissions is developed by the World Resource Institute and the World Business Council for Sustainable Development. Scope 1 covers direct emissions from owned or controlled assets. Scope 2 covers indirect emissions from the purchase and use of electricity, steam, heating and cooling. Scope 3 includes all other indirect emissions that occur in the upstream and downstream activities of an organisation, including purchased services.

with other economic and social activities. As such, the future development trajectory of the DC sector in Singapore is dependent upon a balanced calculation between economic and environmental concerns. The remainder of this report sets out our preliminary findings of how these concerns have been considered by the diverse range of stakeholders in the DC sector.

4. Preliminary findings

4.1 Factors determining Singapore's DC hub status in Southeast Asia

We identified four mutually complementary factors that have shaped Singapore's current DC hub status in Asia Pacific (See Fig. 2)

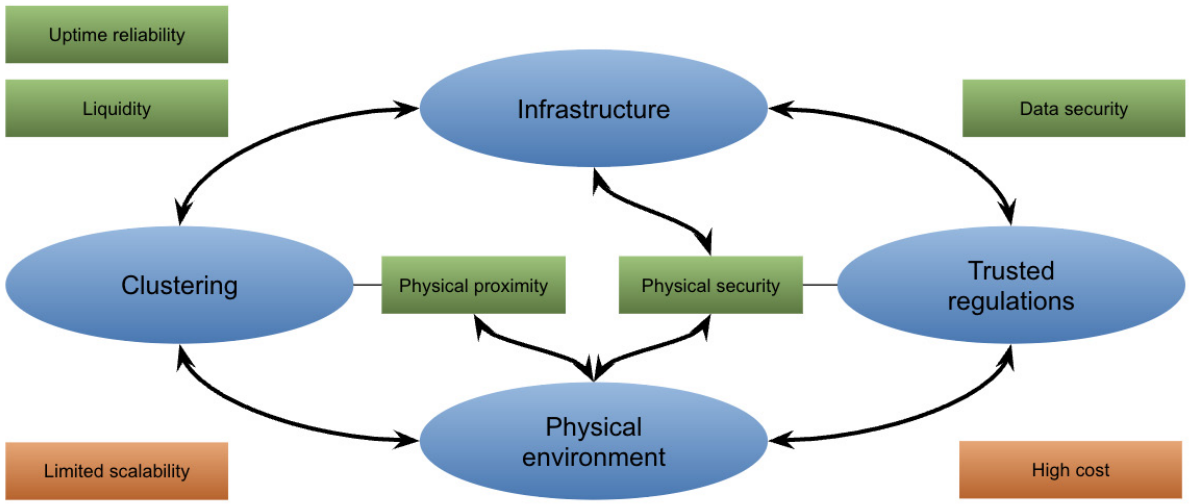

Fig. 2 Visualisation of factors determining Singapore's DC hub status in Asia. Green denotes specific advantages while red indicates limitations.

1. A mature ***infrastructural network*** that effectively supports DC operations. Currently, Singapore is connected to 25 submarine cables, with 14 more under construction (Submarine Cable Map, N.D.), enabling secure and high-speed transmission. This is crucial for low-latency users such as telecommunications, finance, and cloud services. Singapore's reliable energy grid is also a competitive advantage. The high stakes of data workload mean even very short periods of downtime can be financially and reputationally detrimental for a DC operator and their clients.
2. Political stability and ***trusted regulatory environment*** compared to Southeast Asian peers. The country's common law system, strong rule of law, transparency and efficient bureaucracy contribute to ensuring data security, which appeals especially to international players.
3. ***Physical environment*** that is free from natural disasters, such as typhoons, tsunamis, volcanic eruptions, and earthquakes. This makes Singapore a desirable location to build critical infrastructure such as DCs.

4. The combination of the above three factors has led to a ***clustering*** of DC operators and other industry actors, such as infrastructure managers of multinational corporations and investors. This agglomeration effect further drives demand and contributes to a positive feedback loop of enhancing infrastructural availability, attracting investment for further infrastructural development, and enticing highly skilled workers and international corporations to enter Singapore's DC ecosystem.

4.2 An emerging regional DC configuration

The 2019 moratorium brought a sudden halt to Singapore's rapidly growing DC sector. While the Singaporean government justified the moratorium based on important carbon and environmental concerns, it sparked broader discussions about the unique limitations and challenges faced by DCs in Singapore and their prospects.

Respondents unanimously expressed varying levels of frustration towards the moratorium, citing that it squeezed an already tense supply in Singapore, thus driving up costs significantly for DC operators and clients. End users seeking to store sensitive data or requiring a low-latency workload (which place Singapore as the preferred location), have limited choice but to put up with the higher cost. Notwithstanding, informants remain confident in Singapore's continued relevance and competitiveness as a DC hub owing to the 'legacy' of a strong infrastructure, regulatory reliability, and clustering of talent (see Fig. 2).

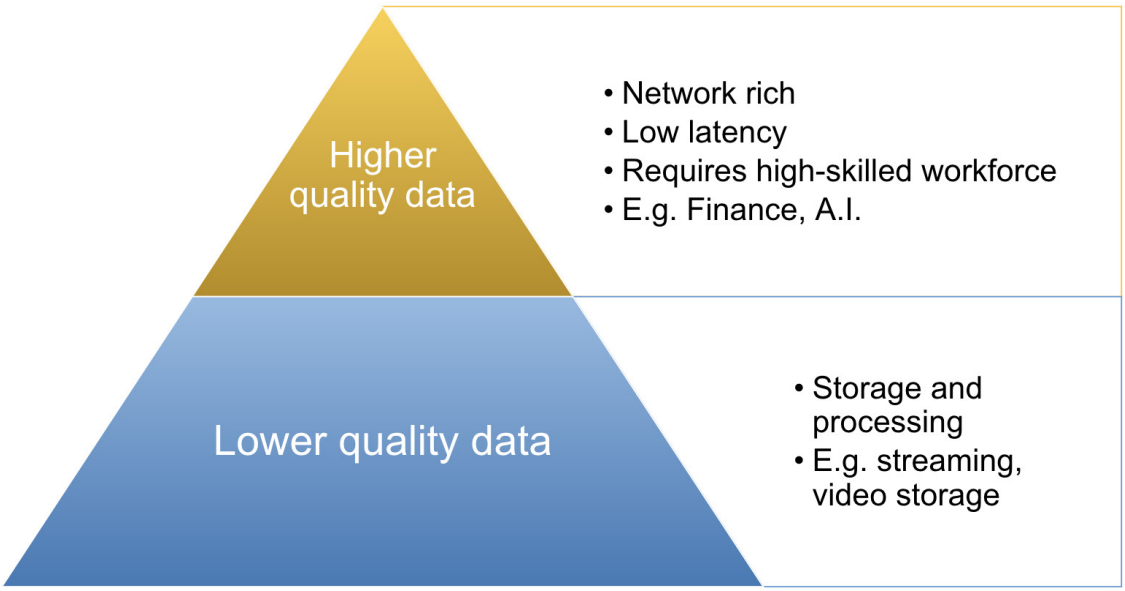

Fig. 3 Hierarchy of DC hubs and workloads

With the prospects of higher cost and increasing limitations on new DCs, some respondents are witnessing certain shifts in DC projects and services in Singapore and neighbouring countries, which could develop into a regional hierarchy of DC services (see Fig. 3). 'High quality' data and workloads that contain sensitive information and with low-latency demand, such as financial trading and AI, will remain in Singapore. These end users are willing to pay

a premium for network-rich workloads to retain in Singapore as they also generate higher economic value. On the other hand, 'lower quality' data mainly used for storage and processing, such as media streaming, cryptocurrency mining, and social media, could move out of Singapore into neighbouring countries where land, energy and labour costs are lower.

4.3 'Singapore-Plus' development trajectories

To support Singapore's data overflow, three key possibilities were suggested (Fig. 4).

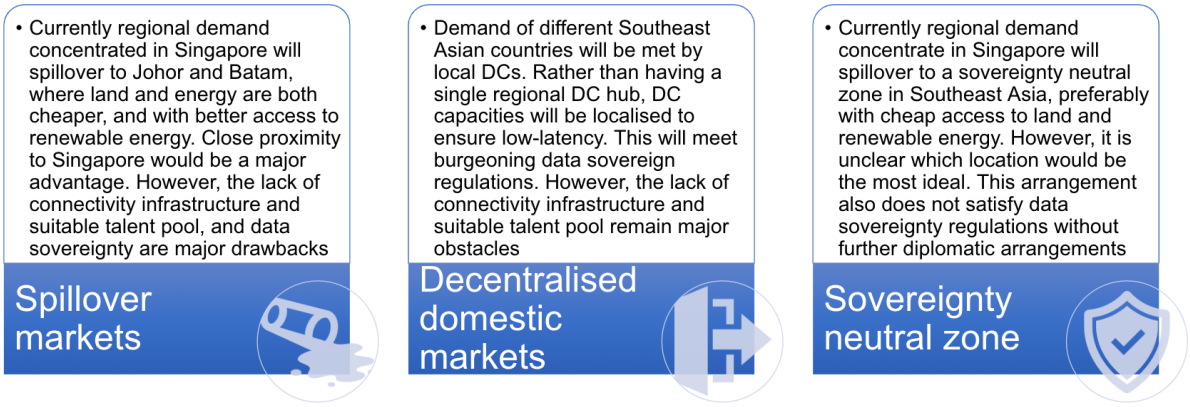

Fig 4. Possible scenarios for a 'Singapore-Plus' DC strategy

1. ***Spillover markets*** such as Johor Bahru and Batam will emerge into prominence. This idea is mooted by global real estate firm Knight Frank and sector specialist DC Byte in a collaborative report that analyses the relative strengths and weaknesses of the two locations as a spillover market to accommodate Singapore's data demands (DC Byte & Knight Frank, 2023). This view was also raised by a number of our respondents in interviews and participants at the stakeholder workshop.
2. A ***decentralised model*** of DCs is commonly suggested, as the other two models were deemed to be too Singapore-centric. As demand for DC services grows throughout the region, it makes business sense to evolve away from having a single DC hub in the region to the dispersal of DC capacities throughout the region. This scenario is deemed highly probable with the emergence of data sovereignty regulations.
3. A ***sovereignty neutral zone*** could be constructed in a location that is physically close to Singapore, such as Johor Bahru or Batam. A special agreement would be required to give the location a unique 'sovereignty neutral' status, akin to a freeport, where highly sensitive data can still be stored securely despite being off Singaporean shores.

Despite the divergence of opinion on the future trajectory of DC networks in Southeast Asia, respondents almost unanimously agreed that there are significant challenges to DC development in emergent Southeast Asian markets.

First, emerging DC markets in the region lack the appropriate infrastructural networks to support high DC workloads. At this stage, the most effective solution to this limitation is gaining government backing to support infrastructural development. Without government backing, the investment landscape is likened to a "cowboy" territory with extremely high risks. Second, and

relatedly, there are challenges in operating in a different political, regulatory and legal environment. Complex bureaucracies and language barriers in other Southeast Asian countries are challenging for international investors and DC developers to navigate. Moreover, respondents noted candidly that corruption remains a significant investment risk, which is not acceptable for many international investors. To navigate these challenges, it is crucial for international developers entering emerging markets to establish a joint venture partnership with a well-established local partner, such as a telecommunications company. Still, none of our respondents were confident about being completely corruption free when conducting business in emerging markets, which would pose key governance and reputational risks.

4.4 Viable sustainability pathways and detecting greenwashing

After the lifting of the moratorium, new DCs in Singapore must meet new requirements including achieving a design PUE of 1.3 or below, obtaining Platinum certification under Singapore's Green Mark for Data Centre criteria, and providing evidence of a clear pathway to achieving 100% renewable energy. More recently, the Infocomm Media Development Authority (IMDA) introduced a new guideline for tropical DCs to support a transition towards 26 degrees Celsius ambient temperature (instead of the current industry practice of 18-22 degrees) in order to enhance energy efficiency (IMDA 2023). While these initiatives are generally welcomed by the DC community as they provide a government-approved pathway to future sustainability and development, there are four key concerns over the economic viability and environmental benefits of some of these new requirements (see Fig. 5).

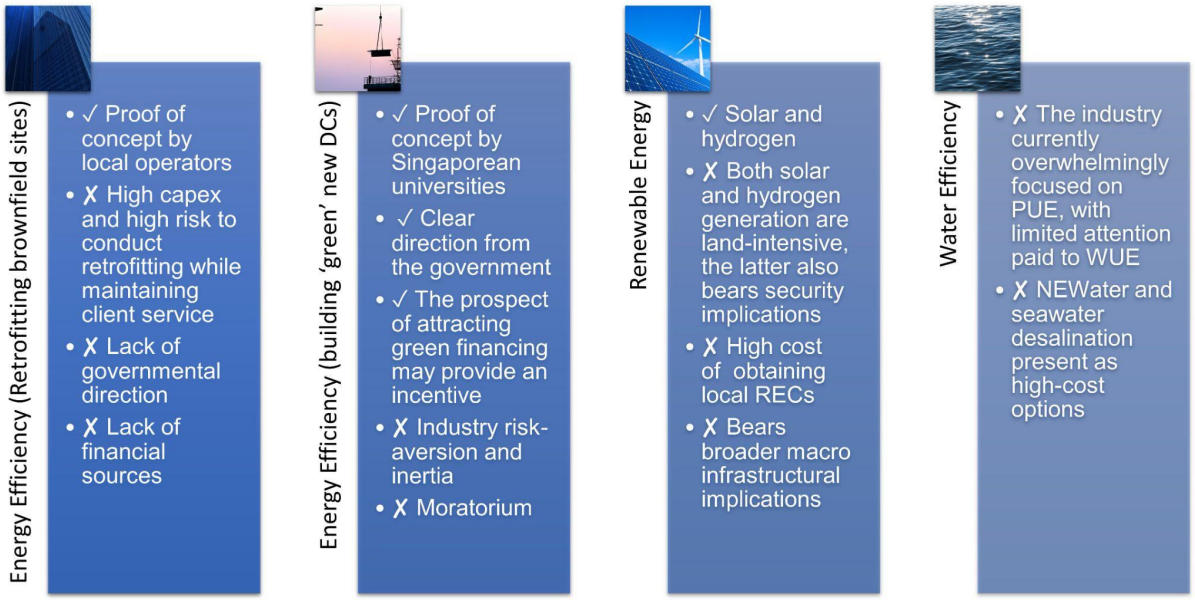

Fig. 5 Key opportunities, challenges, and knowledge gaps in sustainable pathways

1. ***Reliance on Power Usage Efficiency (PUE) as an indicator of sustainability***. PUE indicates the energy efficiency of a DC. As yet, most firms only report their 'design PUE' which assumes 100% utilisation, when in reality most DCs are running at 70-80% at any given time. To address this loophole, the Green Mark for Data Centres, jointly designed and implemented by the Building Construction Authority (BCA) and

IMDA, requires DC in the latest iteration of the standard to disclose a 'PUE curve' that reflects the PUE at different levels of operation (BCA & IMDA 2019). However, the singular focus on operational 'efficiency' draws attention away from deeper questions of gratuitous use of data and ever-growing demands.

2. ***Lack of guidance or incentive for retrofitting existing data centres (brownfield sites)***. Existing IMDA sustainability requirements only apply to new DC applications. There are yet to be any guidelines on how existing DCs, which make up the majority and some of the most inefficient DCs in Singapore, should be retrofitted to reduce their environmental impact. Furthermore, due to the sensitive nature of data and workloads handled in DCs, the sector tends to be very risk-averse. Despite successful testing of low-carbon technologies like immersive cooling, liquid cooling, and raising the ambient temperature of data halls, these innovations have not gained widespread acceptance and adoption. This is also partially due to binding service-level agreements (SLAs) between most DC operators and clients, which can only be reviewed at the end of three- to five-year periods. This, in turn, reduces any incentive for retrofitting brownfield sites.
3. ***Lack of viable renewable energy solutions***. Land scarcity in Singapore poses a challenge in building sufficient solar panels and hydrogen plants to support the country's growing energy demand. Consequently, any Singapore-produced renewable energy is expensive. Efforts to facilitate agreements and infrastructural development to enable renewable energy import from other Southeast Asian countries are at a nascent stage. Moreover, there remain disagreements over international recognition of whether imported renewable energy qualifies for Renewable Energy Certificates and other carbon offsetting schemes, which disincentivises DC operators from importing renewables from the rest of Southeast Asia.
4. ***Water efficiency remains an overlooked sustainability metric***. DCs are not only energy-intensive but also water-intensive, particularly with the increasing adoption of liquid cooling technologies as a more energy-efficient alternative to air cooling methods. However, despite Singapore being a highly water-scarce country, there is limited discussion about the water footprint of DCs. While some international DC operators and cloud companies champion more "sustainable approaches" to water cooling, such as using desalinated water or treated wastewater, informants note that these processes also require significant amounts of energy.

Despite a conservative sectoral culture, DC operators are beginning to commit to various sustainability policies and targets to compete for regulatory approval and attract sustainable financing. However, these efforts were met with scepticism that these firms have not set sufficiently ambitious and meaningful environmental targets. Respondents from the asset management and banking sectors emphasise the absence of reliable quantitative analyses regarding the environmental performance of DCs. As a result, companies could engage in "rating shopping" to find the most favourable sustainability scores, thus undermining the credibility of such assessments.

5. Conclusions and Next Steps

Navigating sustainable pathways for Singapore's DC sector presents environmental, economic, and technical challenges that require the collaboration between experts and policy-makers in digital, environmental, energy and infrastructure, and financial sectors.

Given the complexity of reconfiguring the future economic and environmental sustainability of Singapore's DC sector, it is crucial to have suitable, experienced personnel in leading the sustainability transition. Respondents unanimously pointed to a shortage of talent to navigate this trilemma faced by the sector. As such, the search for talent has been compared to a game of 'musical chairs' where skilled personnel move between DC operators, cloud operators, consultancies, and asset management within short periods of time. In response to this challenge, the government and industry have collaborated to establish subsidised training programmes, for example, data centre engineering training offered by the Institute of Technical Education and Microsoft's Data Centre Academy. However, the fruits of these efforts could only be assessed in a few years' time when inaugural cohorts enter the labour market.

Our interviews and workshop have particularly highlighted the importance of facilitating sectoral interaction and knowledge sharing amongst stakeholders. As the DC sector navigates the uncharted territory of decarbonisation and shifting economic landscapes in the region, a common platform such as an industry association could provide important benefits. In addition to knowledge sharing amongst the diverse range of stakeholders in the sector, such a platform could also function as a collective voice to represent the interests and concerns of the DC sector and engage more effectively with government agencies. This is an especially critical period as Singapore emerges out of the moratorium. To date, SG Tech and the Singapore Computer Society have pioneered early efforts although further consolidation will be required in coordinating sectoral stakeholders.

This study aims to support the sector's effort to identify and scale sustainable DC best practice in Singapore and the broader Southeast Asia region. We aim to conduct another round of interviews and stakeholder engagement in the last quarter of 2023, and welcome contacts and enquiries from industry and policy in the DC sector to share their experience and insights.

Appendix A. Different types of DCs

DC category	Definition
Cloud	In this off-premises form of data centre, data and applications are hosted by a cloud services provider such as Amazon Web Services (AWS), Microsoft (Azure), or IBM Cloud or other public cloud providers.
Colocation	In colocation ("colo") DCs, a company rents space within a data centre owned by others and located off company premises. The colocation data centre hosts the infrastructure: building, cooling, bandwidth, security, etc., while the company provides and manages the components, including servers, storage, and firewalls.
Enterprise	Enterprise DCs are built, owned, and operated by companies and are optimised for their end users. Most often they are housed on the corporate campus.
Hyperscaler	Hyperscale DCs are similar to enterprise DCs, but operate on a much larger scale, typically serving tech giants such as a global cloud or social media company. Owing to the advantages of economies of scale and custom engineering, they typically outperform enterprise DCs.
Managed service DC	Also known as bare metal DCs. These DCs are managed by a third party (or a managed services provider) on behalf of a company. The company leases the equipment and infrastructure instead of buying it.

Source: Cisco (N.D.)

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