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Enabling Pathways for Accelerating Sustainable Data Centre Development in ASEAN

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POLICY BRIEF

Highlights

1. Net-zero carbon intelligent data centres a necessity for ASEAN sustainable digital ecosystem development
2. A taxonomy on net-zero carbon data centres needs to be established
3. The principle of "Next Practice" is an enabler for adopting novel data centre cooling technology
4. A strategic multi-stakeholder approach helps foster conducive policy and regulatory environments

Summary

The rise of high-speed internet, cloud computing and artificial intelligence creates an urgent need for data centres in Southeast Asia to become carbon neutral. Novel cooling technologies are becoming available, but policy, regulation and acceptance remains significant hurdles for adoption. The principle of "Next Practice", supported by a multi-stakeholder approach, is key to accelerate sustainable ASEAN digital economy development.

What's the issue?

Over the past decade, the demand for cloud computing and internet services has surged dramatically, leading to a rapid proliferation of data centres worldwide. Consequently, this expansion has resulted in an exponential rise in energy consumption. In 2022, global data centre electricity consumption was estimated to be between 240 and 340 TWh, accounting for approximately 1 to 1.3 per cent of total electricity consumption (excluding data networks and cryptocurrency mining)[1]. A report by the U.S. Department of Energy (DOE)[2] found that data centres accounted for around 4.4 per cent of total U.S. electricity consumption in 2023, with projections indicating an increase to between 6.7 and 12 per cent by 2028. The report further highlights that electricity usage by data centres in the U.S. rose from 58 TWh in 2014 to 176 TWh in 2023, with an expected increase to between 325 and 580 TWh by 2028.

Deloitte[3] predicts that by 2025, data centres will account for approximately 2 per cent of global electricity consumption, or 536 TWh. However, with the growing demand for power-intensive Gen AI (generative artificial intelligence) training and inference, global data centre electricity consumption could nearly double to 1,065 TWh by 2030. In a fossil fuel-dominated energy system, greenhouse gas (GHG) emissions from

[1] International Energy Agency. "World Energy Outlook 2024 – Analysis - IEA," October 1, 2024.
[2] US Department of Energy. "DOE Releases New Report Evaluating Increase in Electricity Demand from Data Centres," December 20, 2024.
[3] Ramachandran, Karthik, Duncan Stewart, Kate Hardin, and Gillian Crossan. "As Generative AI Asks for More Power, Data Centres Seek More Reliable, Cleaner Energy Solutions." Deloitte Insights, November 19, 2024.

global data centres have risen significantly since 2018 and are expected to account for 3.2 per cent of total global carbon emissions by 2025, increasing to 14 per cent by 2040[4]. The projected growth of the global data centre industry suggests that by 2030, these operations will generate emissions equivalent to 2.5 billion tonnes of GHG emissions[5].

Another significant source of GHG emissions in data centres is the cooling systems, which typically accounts for about 40 per cent of the total data centre energy use. These cooling systems commonly use hydrofluorocarbons (HFCs) as refrigerants. For example, HFC-23 has a global warming potential (GWP) as high as 14,600[6], meaning that one kilogram of HFC-23 has the same warming effect as 14,600 kilograms of carbon dioxide over a 100-year timescale. While the total volume of HFC emissions is much lower than carbon emissions from fossil fuel combustion, the high GWP of HFCs makes them a critical concern. With an annual growth rate of 10 to 15 per cent, HFCs have become the fastest-growing contributor to global warming[7]. The United Nations Environment Programme (UNEP) has warned that unchecked HFC growth could undermine global decarbonisation efforts.

Under the United Nations Framework Convention on Climate Change's Category 2: Industrial Processes and Product Use, which covers net HFC-23 emissions and removals, Annex I parties reported total HFC-23 emissions of 1,431 tonnes in 2021[8]. In response, the Kigali Amendment to the Montreal Protocol was adopted at the 28th Meeting of the Parties in October 2016, aiming to phase down the production and consumption of HFCs in favour of refrigerants with lower GWP values. This amendment came into effect on 1 January 2019, mandating that Group 1 countries completely phase out HFC use by 2045, thus contributing to global climate change mitigation efforts.

The ASEAN (Association of South-East Asian Nations) data centre market is experiencing significant expansion, propelled by the increasing adoption of digital technologies and the region's strategic position as a hub for data storage and processing. Remarks by the Secretary-General of ASEAN reveals that AI could have a strong overall impact, potentially driving a 10 to 18 per cent GDP uplift across Southeast Asia by 2030, equivalent to nearly $1 trillion[9]. As the ASEAN moves towards regional digital integration[10] and seeks to double its digital technology market from Kearney's estimation of US$1 trillion to US$2

[4] Trueman, Charlotte. "Why Data Centres Are the New Frontier in the Fight Against Climate Change." Computerworld, August 9, 2019.
[5] Nurse, Peter. "Global Data Centres to Raise CO2 Emissions Dramatically - Morgan Stanley." Investing.com, September 5, 2024.
[6] Intergovernmental Panel on Climate Change. "IPCC Fifth Assessment Report (AR5)." United Nations Environment Programme, March 2023.
[7] Workman, Caitlin, ed. "Canada and the World Agree to Phase Down the World's Fastest Growing Source of Greenhouse Gas Emissions." Press release, October 15, 2016.
[8] Eriguchi, Takeshi, Jr., Helen Tope, and Jianjun Zhang, eds. "Report of The Technology and Economic Assessment Panel: Volume 5: Response to Decision XXXV/7: Emissions OF HFC-23." United Nations Environment Programme, 2024.
[9] "Remarks by H.E. Dr Kao Kim Hourn, Secretary-General of ASEAN." AI Opportunity Southeast Asia Forum. October 2, 2024.
[10] ASEAN Coordinating Committee on Electronic Commerce. "ASEAN Digital Integration Framework Action Plan 2019-2025," 2019.

trillion[11], sustainable data centres with a net-zero carbon footprint present a crucial pathway for the region's economic and environmental future.

Why is this important?

Despite significant regional efforts to drive the low-carbon energy transition, fossil fuels remain the dominant energy source in ASEAN, posing practical challenges in finding economically viable alternatives. As of 2023, fossil fuels accounted for over 80 per cent of ASEAN's total primary energy supply, with coal, oil, and natural gas continuing to play a critical role in power generation[12]. This dependence on fossil fuels is further complicated by the region's accelerating digital transformation, with countries such as Malaysia, Singapore, and Thailand striving to become major players in artificial intelligence (AI) and high-performance computing (HPC). The increasing computational demands of AI, coupled with the region's hot and humid tropical climate requiring 24/7 active cooling, could significantly hinder ASEAN's energy security and climate commitments if data centre growth remains unchecked[13].

As ASEAN moves towards establishing a sustainable digital ecosystem, there remains an absence of a clearly defined and widely accepted framework for sustainable data centres. Sustainability entails balancing the 'economic, social, and environmental' dimensions, and in the case of data centres, environmental factors include both energy consumption and the use of coolants or refrigerants. While concepts such as green data centres, net-zero carbon data centres, and 24/7 carbon-free energy have been introduced, the lack of a unified sustainability taxonomy for data centres in the region creates ambiguity. Furthermore, there are currently no regional standards governing data centre operations. In most ASEAN countries, data centre-specific regulations are scarce, often falling under general building guidelines[14]. Without a clear and standardised framework, ASEAN risks encountering challenges in ensuring the long-term sustainability of its digital economy development[15].

Traditional air-cooling systems in data centres present several inefficiencies. They require significant energy for air circulation and cooling, and in humid environments, additional energy is needed for dehumidification. Studies suggest that cooling alone can account for 30 to 40 per cent of a data centre's total electricity consumption[16]. In

[11] ASEAN Secretariat. "Digital Economy Framework Agreement (DEFA): ASEAN to Leap Forward Its Digital Economy and Unlock US$2 Tn by 2030." Association of South-East Asian Nations, August 19, 2023.
[12] EU-ASEAN Business Council. "Energy Transition in ASEAN." Singapore, April 2023.
[13] Chu, Amanda, and Alexandra White. "How The US Can Win the AI Race Without Driving up Energy Costs." Financial Times, February 20, 2025.
[14] ASEAN Centre for Energy. "Building Next Generation Data Centre Facility in ASEAN," May 16, 2024.
[15] Setyawati, Dinita, and Shabrina Nadhila. "ASEAN's Clean Power Pathways: 2024 Insights." EMBER, October 22, 2024.
[16] Boyd Corporation. "Energy Consumption in Data Centres: Air Versus Liquid Cooling." Boyd | Trusted Innovation (blog), July 28, 2023.

contrast, immersion liquid cooling technology offers substantial benefits. By directly submerging IT hardware in thermally conductive dielectric fluids, this method achieves much higher heat transfer efficiency. It allows data centres to operate at lower temperatures with reduced energy input, potentially cutting energy consumption for cooling by 40 to 50 per cent[17]. Additionally, many immersion cooling fluids are non-ozone-depleting and have low global warming potential (GWP), thereby minimising their environmental impact. The adoption of immersion cooling can significantly lower a data centre's carbon footprint, contributing to a shift towards net-zero operations. Furthermore, its superior heat dissipation efficiency aligns with broader sustainable development goals, making it a viable solution for reducing both energy demand and reliance on harmful refrigerants.

ASEAN has a unique opportunity to develop a sustainable digital economy from the outset, as many of its member states are still in the early stages of digital transformation. Unlike regions that must retrofit legacy infrastructure, ASEAN can integrate sustainability principles into new data centre developments. Advanced technologies, including high-efficiency cooling systems and AI-driven energy optimisation, are now more readily available, providing data centre operators with viable pathways to reduce emissions and operational costs. Moreover, ASEAN is endowed with vast renewable energy resources, including solar, wind, and hydropower, although their distribution and accessibility vary across member states[18]. By strategically leveraging these renewable resources and implementing stringent sustainability frameworks, ASEAN can establish a resilient, low-carbon digital infrastructure that supports both economic growth and environmental responsibility.

What should the policymakers do?

1. Establish a sustainable data centre taxonomy taking into consideration best-in-class and emerging technologies.

A robust and forward-looking sustainable data centre taxonomy is essential for guiding industry players and investors towards greener practices. Policymakers should develop a comprehensive framework that incorporates globally recognised and emerging sustainability metrics, such as Power Usage Effectiveness (PUE), Water Usage Effectiveness (WUE), and Carbon Usage Effectiveness (CUE). PUE measures energy efficiency, with a lower ratio indicating better performance. WUE serves as a key indicator of responsible water consumption in data centres, while CUE links data centre operations to carbon emissions.

[17] Jie, Yang. "Novel Ideas to Cool Data Centres: Liquid in Pipes or a Dunking Bath." Wall Street Journal. August 11, 2024.
[18] International Energy Agency. "Southeast Asia Energy Outlook 2024." Paris, France, October 2024.

By setting a progressive roadmap, ASEAN member states can establish increasingly stringent sustainability targets that evolve with technological advancements. Regular updates should be incorporated to reflect improvements in renewable energy integration, energy-efficient cooling, and AI-driven optimisation. The taxonomy should not only define minimum standards but also incentivise continuous innovation towards net-zero carbon operations.

2. Establish policy, regulatory, and legislation frameworks on sustainable data centre by leveraging commercial pilots of advanced technologies.

Governments should commission commercial pilots of advanced data centre technologies using a vendor-agnostic approach. This allows policymakers to evaluate the real-world feasibility of next-generation cooling solutions, AI-driven energy management, and on-site renewable energy integration. It also enables them to identify gaps in industry standards, regulations, and legislation by studying implementation challenges and operational best practices.

Furthermore, insights gained from these pilot projects can guide the development of targeted policy interventions, such as tax incentives, green financing mechanisms, and carbon pricing structures. Establishing clear policy and regulatory roadmaps based on pilot project learnings ensures that sustainable data centre initiatives align with national climate commitments while supporting the expansion of the digital economy.

3. Adopt the principles of "Next Practice" in national policy and strategic planning for accelerating the use of advanced technologies.

To address these challenges effectively, ASEAN must embrace the principle of Next Practice rather than merely implementing current best practices. Next Practice represents a paradigm shift—fundamentally reimagining solutions through innovative thinking and transformative technologies rather than relying on incremental improvements. Unlike best practices, which optimise existing methods, Next Practice anticipates and addresses future challenges through disruptive innovation. Implementing Next Practice principles requires creating safe spaces for experimentation with emerging technologies while incentivising solutions that deliver order-of-magnitude improvements rather than marginal gains. Policymakers should establish regulatory sandboxes specifically for Next Practice data centre technologies, allowing innovative approaches to be tested without being constrained by outdated regulatory frameworks. Additionally, performance-based regulations should be developed to reward outcomes rather than prescribe specific technologies, enabling the market to drive the adoption of optimal Next Practice solutions.

Public-private partnerships should be leveraged to accelerate the research, development, and deployment of breakthrough technologies that embody Next Practice principles, moving beyond incremental efficiency improvements to fundamentally reimagine data centre sustainability. Public-private partnerships can provide critical funding and regulatory support for disruptive solutions, while government-led digital skills training programmes ensure that industry professionals are equipped to implement and scale these innovations. By embedding Next Practice principles into national policy frameworks, ASEAN countries can transition away from outdated, energy-intensive models and establish themselves as global leaders in transformative digital infrastructure. This proactive approach will not only enhance economic competitiveness but also drive long-term environmental and social sustainability.

4. Liquid cooling as a "next technology" for setting reference pathways for sustainable data centre development.

Immersion liquid cooling presents a game-changing opportunity to decouple digital economy growth from energy and water consumption as well as carbon emissions. Compared to traditional air cooling, immersion cooling can reduce energy consumption for cooling by 40 to 50 per cent while minimising water use—critical for water-stressed regions. Additionally, it enhances computing efficiency, enabling high-density AI workloads while maintaining lower operational costs. However, immersion liquid cooling is not merely an incremental improvement but a Next Technology—a disruptive innovation that redefines cooling strategies rather than optimising existing methods. By eliminating reliance on air circulation altogether, immersion cooling delivers up to 50 per cent cooling energy savings, reduces water consumption by 95 per cent, supports power densities up to 100kW per rack, and cuts total carbon footprint by 25 to 30 per cent. Beyond efficiency improvements, it transforms data centre infrastructure by removing the need for raised floors, air handlers, and complex refrigerant networks.

The successful adoption of 'next technology' like immersion cooling requires a Next Practice approach—one that moves beyond conventional best practices and embraces transformative solutions. ASEAN nations should integrate immersion cooling into national data centre policies by establishing regulatory sandboxes that facilitate real-world testing, incentivising early adoption through green financing and certification schemes, and mandating performance benchmarks that drive high-efficiency cooling adoption. Additionally, a regional knowledge-sharing platform should be developed to accelerate best-practice dissemination across ASEAN markets. Given the technical unfamiliarity, supply chain constraints, and regulatory uncertainties associated with Next Technology, a coordinated policy and industry effort, underpinned by Next Practice, will be essential to overcoming these challenges and ensuring widespread implementation.

5. Embrace the principle of "knowledge and innovation without borders" in accelerating regional multi-stakeholder approaches when scaling up novel cooling technologies for intelligent data centres.

ASEAN policymakers should prioritise regional collaboration under the principle of "Knowledge and Innovation Without Borders," ensuring a technology- and vendor-agnostic approach that fosters competition and encourages the adoption of most appropriate and potentially forward-looking solutions. A regional-aware but nationally focused strategy should be developed to align with each country's energy landscape and digital infrastructure goals. Cross-border partnerships between governments, academia, and industry leaders should be strengthened to scale up sustainable cooling technologies. By embedding Next Practice in policy innovation, ASEAN can move beyond fragmented national efforts and establish a unified framework that accelerates the adoption of high-efficiency cooling solutions across the region.

The convergence of AI expansion and Next Practice adoption is not just beneficial—it is essential. AI models are experiencing exponential growth in computational requirements, with each new generation demanding up to 100 times more processing power. If ASEAN continues to rely on conventional data centre designs, energy consumption could surge by 200 to 300 per cent, water consumption by 200 to 250 per cent, and carbon emissions by 25-40 million tonnes annually by 2030. Conventional optimisation strategies alone will not be sufficient to bridge the gap between ASEAN's digital ambitions and sustainability targets. Without Next Practice solutions such as immersion cooling, ASEAN risks an unsustainable trajectory. Conversely, by prioritising Next Practice approaches and embracing "knowledge and innovation without borders", ASEAN can establish a sustainable cycle where AI-driven digital growth accelerates the sustainable infrastructure and economic development.

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Biography

Dr Victor Nian is Founding Co-chairman of the Centre for Strategic Energy and Resources. His expertise spans energy and climate policy, sustainability and net-zero strategy, long-term planning, and industrial economy. He is a recognised expert in nuclear energy, digital transformation, and sustainability governance in Southeast Asia. He advises public and private organisations on geopolitics and market dynamics of strategic and/or sensitive technologies to support decision-making. He leads efforts in technology commercialisation, value chain development, and fostering private-public collaboration to accelerate the energy transition and digital economy in emerging Asian markets. He holds a PhD in Mechanical Engineering and a BEng (Hons) in Electrical Engineering with a Minor in Management of Technology from the National University of Singapore.

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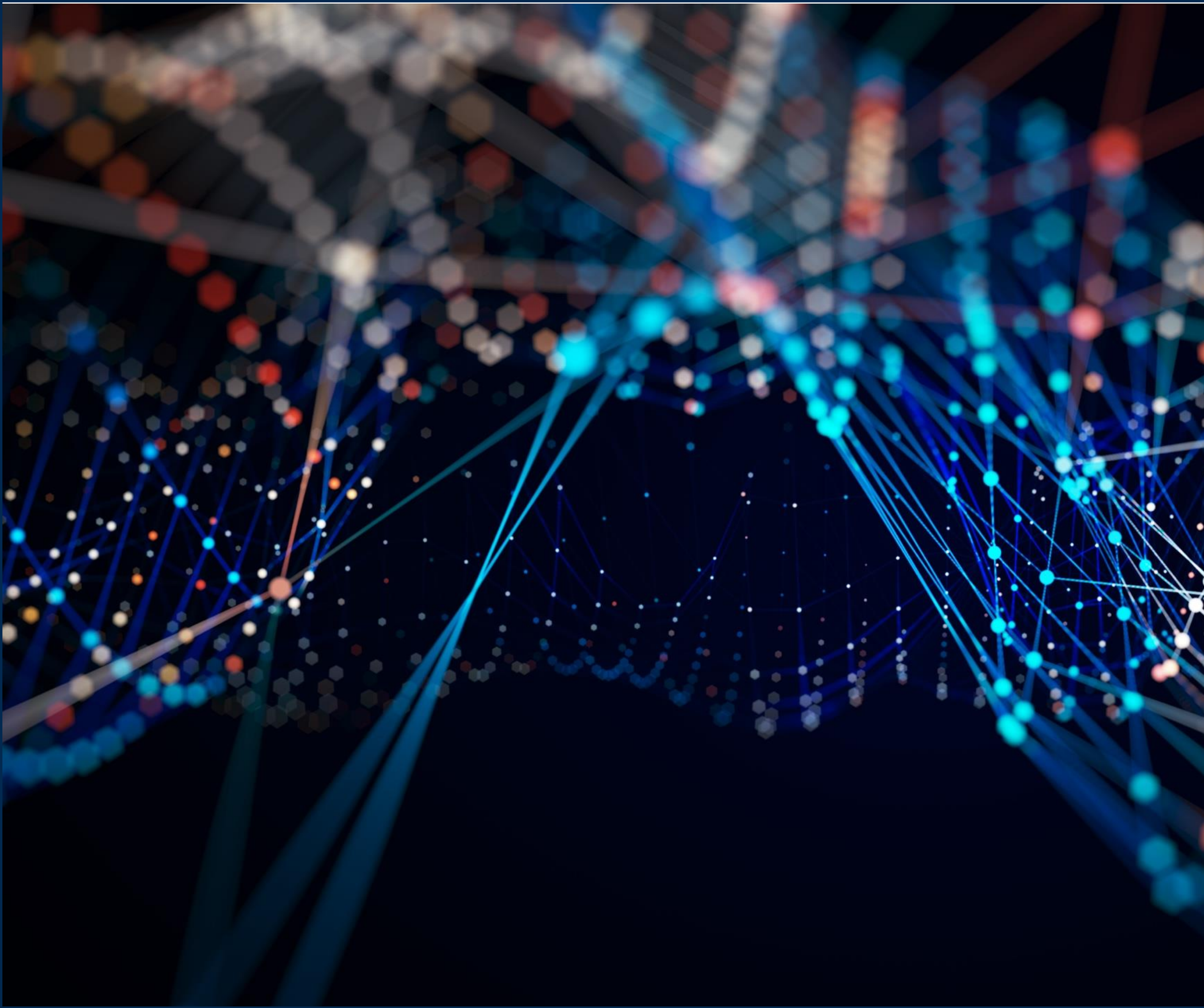

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