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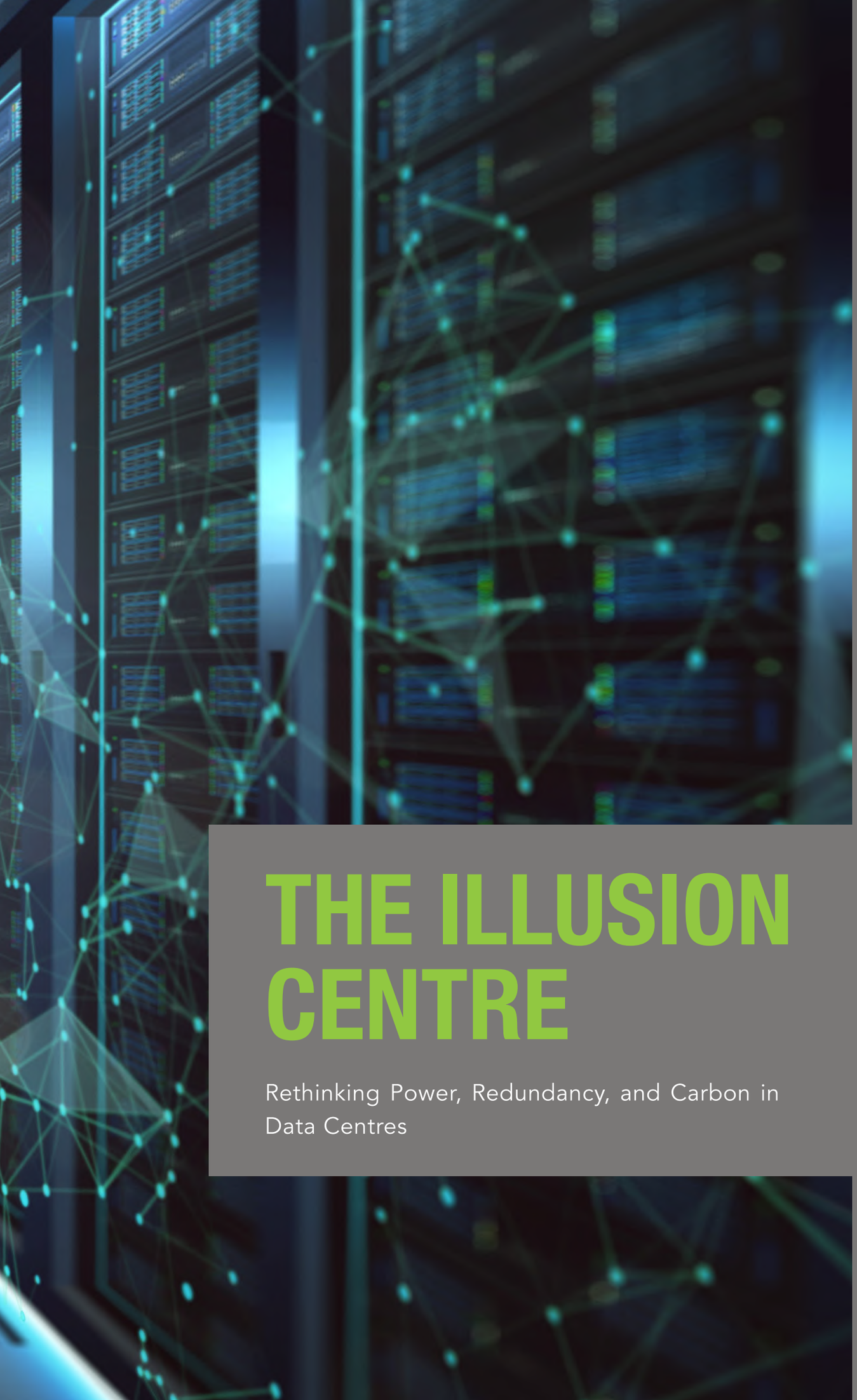
SINGAPORE GREEN BUILDING COUNCIL

BUILDING GREENER DATA CENTRES FOR A SUSTAINABLE DIGITAL FUTURE

INSIDE:



THE ILLUSION CENTRE

Rethinking Power, Redundancy, and Carbon in Data Centres

Each of us today carries an obligation to respond to the climate crisis. How we meet that obligation is entirely up to us-not the planet-and depends on the integrity, ambition, momentum, and effectiveness of our strategies. Some approaches, though well-intentioned, do not deliver the speed or scale required for meaningful climate mitigation and adaptation. Others rely on illusions: low- to medium-impact technical fixes, short-term sustainability credentialism, clever accounting, and selective metrics that paint a reassuring picture while quietly slowing progress and shrinking impact.

Few sectors exemplify these contradictions as glaringly as the ballooning data centre industry.

Data centres present a profound paradox-one that reveals a fundamental incompatibility with the natural world. Modern civilisation cannot function without them; they are the axis around which our digital economy rotates. And yet, they are among the fastest-growing drivers of global energy demand, a demand our world is already struggling to meet sustainably. Beyond energy, these facilities are water-guzzlers and waste factories.

So how do we resolve this paradox? The first step is to identify and dismantle the illusions these digital fortresses offer us.

UNDERSTANDING THE ILLUSIONS

The Power Illusion

"We are green because we have a low PUE."

Power Usage Effectiveness (PUE) has become the industry's calling card. But how often do we ask where the power actually comes from? Or what type of energy is being used? Annualised or averaged PUE figures can mask systemic inefficiencies, underutilisation, and wasted energy at partial loads. A fixation on efficiency metrics, without a system-level understanding of energy sourcing and consumption, creates a dangerously incomplete picture.

To move forward, operators and the wider data centre ecosystem must go beyond PUE and embrace system-level approaches to energy use, accounting for source, timing, and real-world grid impacts.

The Redundancy Illusion

"We are green because we have a low PUE."

Redundancy is not inherently virtuous. And redundancy does not equal resiliency. Is redundancy right-sized and aligned with workload criticality? Or does overbuilt redundancy (over-redundancy) conceal outsized energy, fiscal, and embodied carbon footprints from duplicated structure, equipment, and hardware? Resilience should never be an excuse for overprovisioning, which can lock in both capital inefficiency and long-term carbon debt.

The Carbon Illusion

"We are green because we are operationally efficient."

Operational efficiency alone does not equate to climate responsibility. Has efficiency been assessed against scope 2 emissions from grid electricity? Has scope 3 been meaningfully considered? Absent a whole-life carbon perspective, "green" data centres compromise their ecological status.

WHO HOLDS THE LEVERS?

Breaking these illusions requires recognising where control truly lies. For data centre developers and operators, solutions can emerge across three types of levers:

- High-control levers: capital allocation, design decisions, sustainability planning
- Context-based levers: site characteristics such as climate, infrastructure, and local constraints; facility characteristics such as size, legacy systems, age, massing, form
- Limited-control levers: grid energy mix, regulation, policy, market structures, sustainable finance instruments

Success depends on maximising high-control levers while proactively shaping the limited-control ones through advocacy, market signalling, and collaboration with policymakers, regulators, and financiers.

This becomes especially urgent when we consider industry trajectory. By 2029, hyperscalers are expected to command an even larger share of global critical IT load (Synergy Research Group, n.d.). For the sector to decarbonise as a whole, strategies within the limited-control bucket must evolve rapidly. Policymakers, banks, and regulators

will need to work alongside operators and developers to ensure that deep decarbonisation is achievable at scale, across the value chain.

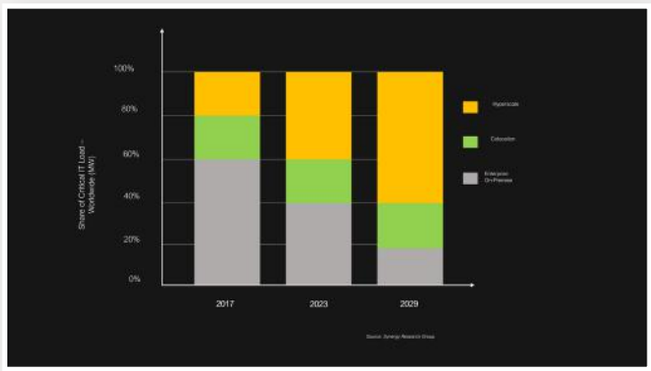


Figure 1. Share of Critical IT Load by 2029 (Synergy Research Group, n.d.)

With the stakes clear, we can now examine how operators and developers can unravel each illusion in practice.

BREAKING THE POWER ILLUSION

The most persistent issue here is energy sourcing. What energy is being used, and where is it coming from?

Renewable energy is the lynchpin. But globally, we face a serious shortfall. At COP28 in 2023, 120 countries pledged to triple global renewable capacity to around 11.2 TW by 2030. Meeting that target would have required annual growth of at least 16.1 percent from 2022 onward. Both 2023 and 2024 fell short, meaning renewable deployment must now accelerate even faster (IRENA, Renewable Energy Statistics 2025).

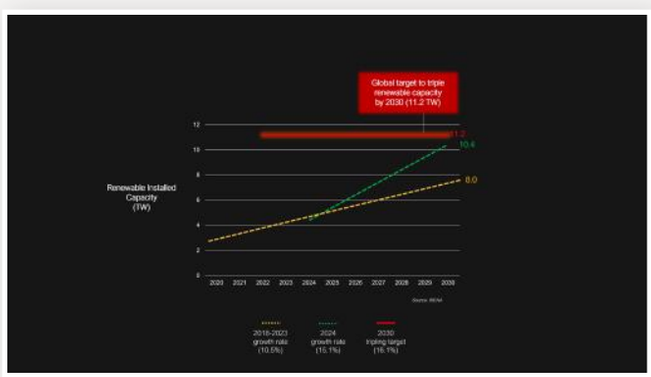


Figure 2. Renewable Installed Capacity Trends (IRENA, Renewable Energy Statistics, 2025)

This shortfall is not merely technical, it is structural. Clean energy infrastructure is not scaling because demand signals are insufficient. Grids need credible, locational demand to justify investment, and data centre operators are singularly positioned to provide it.

Consider a data centre in Singapore. When this data centre matches its annual electricity consumption with renewable energy certificates (RECs) or offshore Power Purchase Agreements (PPAs), it may appear carbon-free on paper. But in reality, the local Singapore grid (where the data centre operates) is predominantly gas-powered and will still burn fossil fuels, especially at night when solar is unavailable; so the data centre is still physically using fossil electricity. This creates a mismatch between carbon accounting and actual decarbonisation because the demand signal goes to a foreign grid (like Australia), not the local grid balancing area. The Singapore grid operator sees no difference in real-time demand or supply-and so there is no additional pressure to decarbonise grid mix.

Hourly carbon-free energy (CFE) matching crucially alters this dynamic. By reporting and procuring clean energy on an hourly basis within the local grid, operators must align consumption with real, local clean generation. What this does is create tangible demand for local renewables, giving utilities and developers a reason to build them. Unlike annual matching, CFE reporting cannot be achieved through accounting alone: it requires physical decarbonisation.

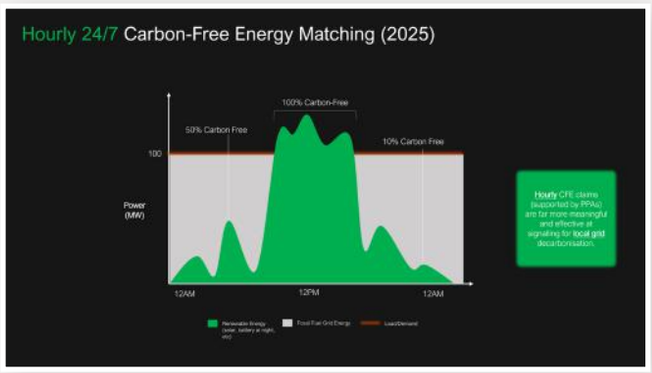


Figure 3a. Hourly 24/7 Carbon-Free Energy Matching (2025)

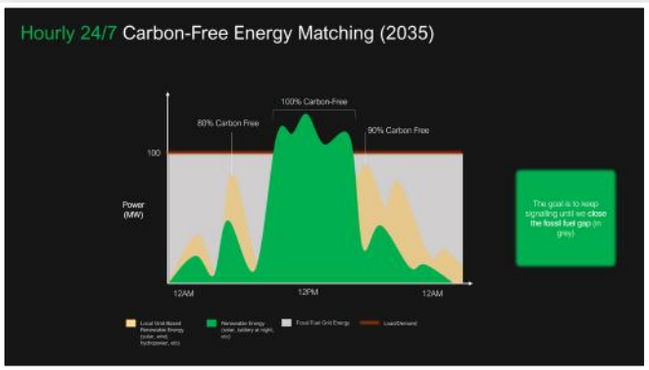


Figure 3b. Hourly 24/7 Carbon-Free Energy Matching (2035)

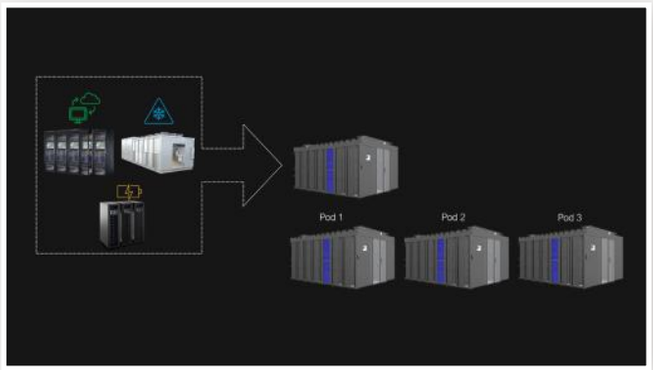


Figure 4. Modularity (Illustration)

When paired with complementary strategies (such as demand response, dynamic load management, renewables-focused business planning, and strategic site selection), hourly CFE can become a powerful lever for system-level change.

At the facility level, problems are compounded by PUE-driven efficiency illusions. Data centres are rarely fully utilised, yet they are designed for peak load. According to Uptime Institute's Global Data Centre Survey 2024, 25percent of facilities operate below 40 percent utilisation (Uptime Institute Global Data Center Survey 2024 et al., 2024). The result is oversized infrastructure running inefficiently for most of its life, a problem that leads directly to the next illusion.

BREAKING THE REDUNDANCY ILLUSION

Why do we build idle infrastructure in the first place? Redundancy is critical for data centres, but how much redundancy do we actually need?

This is where data centre investors must pay attention. Over-redundancy bleeds money in two ways. First, it wastes capital on overbuilt infrastructure. Second, it wastes energy through the knock-on effect of idle servers (they still draw power), which in turn wastes operational money.

Technical, design-led efforts like strategic modularity and phased build-out offer a compelling alternative. By right-sizing redundancy within modular pods and expanding infrastructure in line with demand, facilities can operate closer to optimal efficiency curves. Utilisation improves, energy waste declines, and resilience is maintained without excess.

Tenants also play a crucial role. Honest, well-considered load forecasting enables designers and operators to implement scalable, modular solutions, though this depends on ownership structures and the degree of control operators hold.

Critically, redundancy must be addressed as part of an integrated strategy. Partial-load PUE analysis, high-efficiency systems, virtualisation, and modular design achieve far more together than in isolation. And the embodied carbon implications of redundancy lead us directly to the final illusion.

BREAKING THE CARBON ILLUSION

Carbon is often marginalised in data centre conversations. We need to remind ourselves why carbon matters. Climate science is clear: carbon budgets are finite. For a 1.5°C pathway, humanity has already emitted roughly 2,600 $GtCO_2$ since 1850. From 2025 onward, we have approximately 130 $GtCO_2$ remaining. At current emission rates of around 40 $GtCO_2$ per year, that budget will be exhausted within three to four years (Forster et al, 2025). We do not want this to happen.

Figure 5. 1.5C Carbon Budget Scenario

Now, as the grid/energy supply becomes cleaner, the relative importance of embodied carbon increases. Supply chain emissions—from materials, manufacturing, transport, and equipment—are conservatively at least double operational emissions. This makes whole-life carbon thinking non-negotiable.

Circularity must be embedded from the outset, before design even begins. This requires infrastructure, policy, and market mechanisms that support circular outcomes across the entire lifecycle: modular design, design for disassembly, procurement for reuse, extended refresh cycles, and robust end-of-life pathways including take-back programmes, recovery, recycling, resale, and reuse.

Regulatory and financial frameworks must reinforce this shift. Incentives for circularity, penalties for waste, and green finance instruments linked to circular performance and material efficiency could all play a role.

But none of this can manifest spontaneously. Stakeholders across the value chain must actively create this demand for circularity. Without it, circular infrastructure, along with the ecosystems that support it, cannot and will not materialise.

ECOSYSTEMIC CHANGE

What the data centre sector truly needs is scale and speed. And it needs these two things on ecosystemic and cross-sectoral levels. The final and potentially the most disabling illusion is the belief that data centre decarbonisation is merely a built environment problem. It is not. It is an ecosystemic challenge spanning energy, technology, manufacturing, finance, regulation, and digital infrastructure.

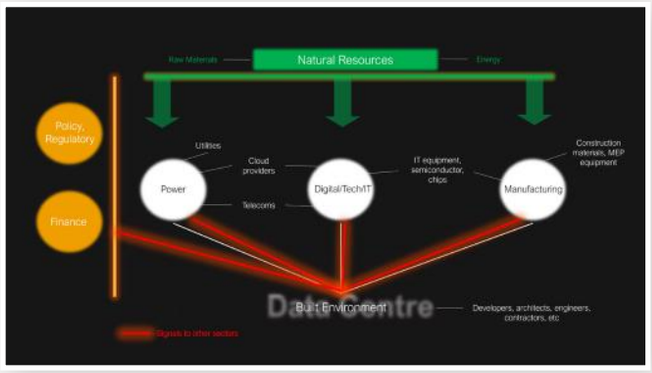


Figure 6. Data Centre Ecosystem Map

The built environment sector cannot solve this alone. Improvements within its boundaries are necessary but wholly insufficient. We must reach beyond traditional sector lines, engage multiple systems simultaneously, and hold all stakeholders accountable for progress. Signals must be sent in every direction. Quickly.

That is the real challenge. And that is the final illusion to break.

So the question remains: how will you reach beyond your sector and help decarbonise the entire data centre ecosystem?

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Cundall

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