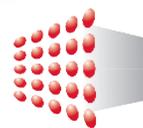


ESI Bulletin



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ESI Bulletin on Broadening Climate Action Beyond Carbon (Volume 20 / Issue 1 · February 2026)



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INTRODUCTION

The main theme of this issue is Broadening Climate Action Beyond Carbon.

Carbon emissions have become the primary indicator for climate action. Net-zero targets, greenhouse gas inventories, and carbon disclosure frameworks increasingly shape policy development, corporate strategies, and investment decisions across various sectors, such as energy, digital infrastructure, and the built environment. This focus has played an important role in mobilising action, enabling comparability, and aligning stakeholders around a common and measurable objective. However, such a carbon-centric approach may not fully capture wider environmental implications.

Given the interconnected nature of environmental systems, there is a need to examine non-carbon impacts to ensure that emissions reductions are achieved without shifting pressures to other areas, such as water resources or material supply chains, which could affect system resilience and long-term sustainability.

This Bulletin brings five articles that examine the energy transition beyond carbon alone. The contributions explore how carbon-focused decision-making can overlook broader environmental impacts, the role of short-lived climate forcers in shaping near-term warming, sectoral pressures emerging from digitalisation and the built environment, and the evolution

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of analytical and reporting frameworks that support more integrated approaches to climate action.

The first article by Ms. Leanne Chew Shee Jia introduces the concept of carbon tunnel vision and examines how an increasingly dominant focus on carbon emissions can unintentionally shift environmental pressures elsewhere. Using examples from refrigerant transitions, electrification, and bio-based fuels, the article illustrates how carbon-focused decisions may obscure impacts on water, land, materials, and ecosystems, highlighting the importance of recognising environmental trade-offs early in the decision-making process.

The second article by Mr. Hoy Zheng Xuan and Dr. Shirleen Lo Lee Yuen examines the role of short-lived climate forcers in shaping near-term climate outcomes. The article explains how pollutants such as methane, black carbon, and ozone precursors exert strong global warming effects despite their relatively short atmospheric lifetimes. It also discusses the evolving reporting landscape for these pollutants, including forthcoming IPCC methodological guidance, and considers how their mitigation can complement long-term carbon reduction strategies.

The third article by Ms. Lalitha Ravi focuses on the growing water footprint of data centres in Southeast Asia as digital infrastructure expands. The article analyses how rising cooling demand translates into increased water use and operational risk, particularly in rapidly developing regional hubs. It discusses metrics such as Water Usage Effectiveness, emerging cooling technologies, and governance approaches, highlighting the need for water-smart planning alongside energy-efficient data-centre development.

The fourth article by Mr. Christian Allen E. Jimenez examines material waste from wiring and piping systems in the built environment. The article highlights how short component lifespans, complex material compositions, and performance-driven design standards limit reuse and recycling outcomes. By analysing end-of-life pathways for metals and plastics, it draws attention to recurring, non-structural material flows that are often overlooked in circular economy and decarbonisation strategies.

The fifth and final article by Mr. Alvin Ee Wei Liang examines why carbon accounting frameworks such as the GHG Protocol increasingly need to be complemented by circular economy reporting. The article introduces the Global Circularity Protocol for Business and explains how it provides a structured reporting architecture for material flows and circularity performance. It highlights how integrating circular economy considerations into reporting can improve transparency, governance, and decision-making as sustainability reporting evolves beyond carbon alone.

Taken together, these articles underscore the increasingly complex and interconnected nature of the energy transition as decarbonisation efforts advance across sectors. While carbon emissions remain central to climate action, the contributions in this issue illustrate how

energy transitions interact with broader environmental pressures, including water use, material demand, waste generation, and near-term climate forcing. They highlight the importance of recognising system-wide interactions rather than addressing emissions in isolation. As countries and industries continue to pursue their climate commitments, the insights presented in the articles emphasise the value of broadening the framing of climate action. Addressing climate change effectively will require continued research, innovation, and policy development that account for the interconnected nature of environmental systems. By bringing together diverse sectoral, analytical, and governance perspectives, this issue contributes to ongoing discussions on how energy transition pathways can be designed to be not only low-carbon but also resilient, resource-aware, and sustainable over the long term.

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Carbon Tunnel Vision: When Cutting Emissions Shifts Environmental Pressures Elsewhere

Ms. Leanne CHEW Shee Jia, ESI Research Associate

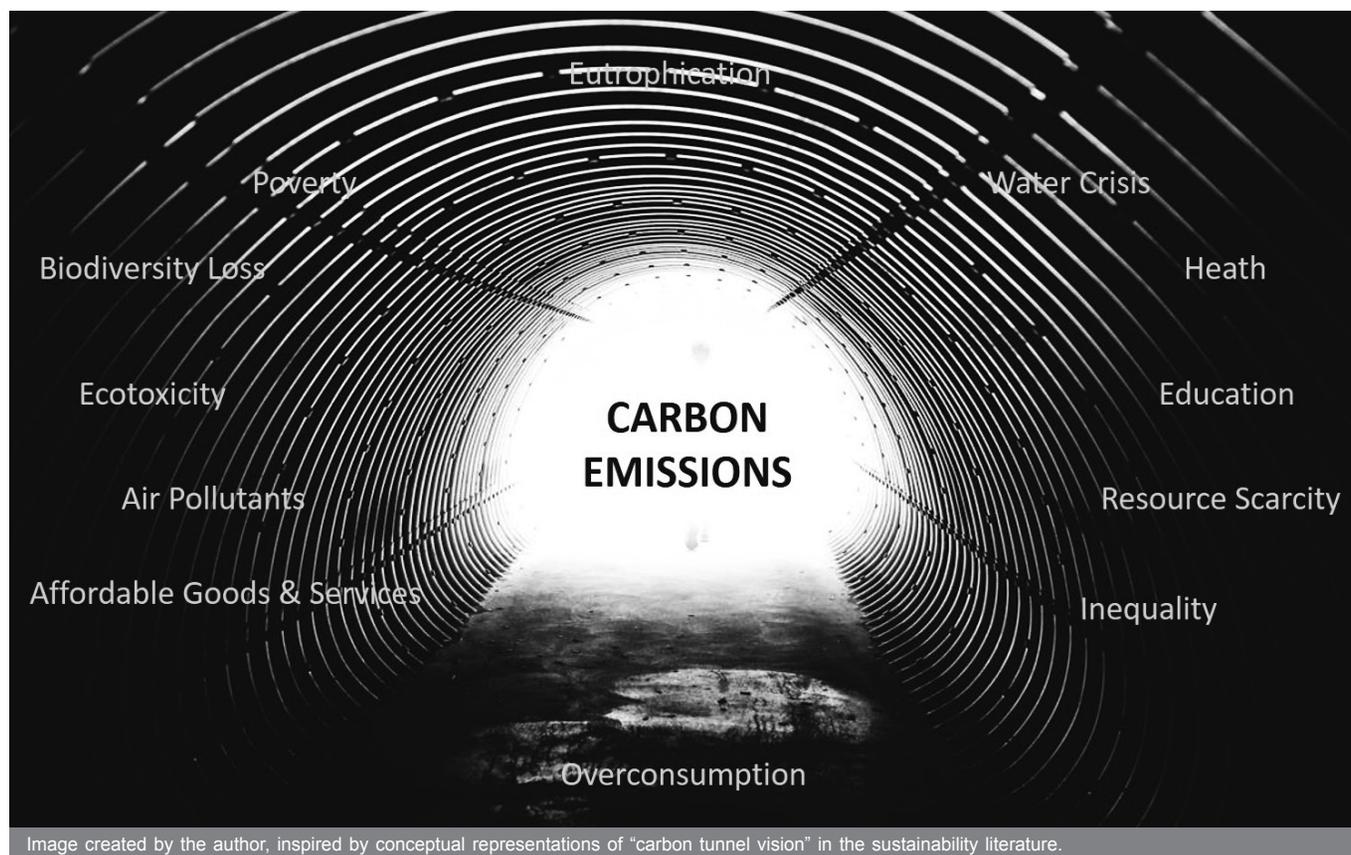


Image created by the author, inspired by conceptual representations of “carbon tunnel vision” in the sustainability literature.

Introduction

Climate change is no longer an esoteric topic discussed only in expert reports. Today, carbon emissions shape everyday conversations about the environment. Governments set net-zero goals, companies highlight their carbon footprints, and consumers are increasingly encouraged to compare products based on how much greenhouse gas (GHG) they produce. This growing attention has brought climate change from a distant concern into mainstream public discussion and decision making.

Environmental history shows, however, that such a strong focus on a single objective can sometimes shift impacts rather than eliminate them. In the past, efforts to protect the ozone layer successfully phased out ozone-depleting substances, chlorofluorocarbons (CFCs), but the replacement chemicals, hydrofluorocarbons (HFCs), proved to have significant climate impacts. A solution designed to address one environmental problem inadvertently contributed to another. This does not diminish the success of ozone protection, but highlights how environmental priorities and knowledge evolve over time. More broadly, environmental governance often involves balancing multiple objectives. When attention is concentrated on a particular indicator, decisions may be structured around that objective, while other dimensions are addressed through separate processes. As environmental systems are multi-dimensional,

improvements along one dimension do not automatically translate into broader environmental gains.

Today, a similar pattern can be observed in climate action, where carbon emissions have become the dominant signal guiding decisions. This phenomenon is referred to here as carbon tunnel vision, a tendency to prioritise carbon reductions so strongly that other environmental and resource impacts carry less weight in decision-making. As carbon metrics increasingly shape policies, investments, and technology choices, understanding how this focus influences outcomes becomes essential.

The Problem: When Carbon Becomes the Only Signal

The problem with carbon tunnel vision is not that carbon emissions are prioritised, but that in some decision contexts, carbon performance can become the primary basis for comparing options when broader environmental trade-offs are involved. Carbon indicators were designed to track climate impacts, yet they are increasingly used to judge whether technologies, investments, and policies are considered sustainable. Carbon plays this role because it fits easily into decision systems. Emissions can be measured, compared across sectors, and linked directly to targets and incentives. However, when emissions reduction targets serve as the central organising objective, carbon performance can carry greater weight in resolving trade-offs between alternatives. In such situations, improvements in carbon

metrics do not necessarily reflect changes across other environmental dimensions. Recognising this dynamic does not diminish the importance of emissions reduction. Rather, it highlights the value of holistic environmental evaluation.

Possible Examples of Carbon Tunnel Vision

A few examples of carbon tunnel vision and its impact shifting are summarised in Table 1.

Table 1. Examples of carbon tunnel vision and impact shifting

Climate-focused action	What carbon-focused decisions prioritise	Where impact shift
Phase-down of high-GWP refrigerants (HFCs)	Sharp reduction in climate impact from refrigerant leakage	Increased use of low-GWP refrigerants such as HFOs, which can break down into persistent by-products (e.g., TFA) that accumulate in water systems
Electrification of energy and transport systems	Lower operational and lifecycle carbon emissions	Increased demand for critical minerals, land disturbance from mining, water pollution, and expansion of energy infrastructure
Bio-based fuels	Reduced net emissions	Competition for land, pressure on biodiversity, and increased water use

Source: Author's summary based on synthesis of publicly available literature documents.¹

1) Refrigerant Transition and Chemical Persistence

The global agreement to phase down refrigerants with high global warming potential (GWP), such as HFCs, under the Kigali Amendment is widely seen as a major climate success. HFCs were commonly used in air-conditioning and refrigeration systems and are extremely potent GHGs, meaning even small leaks can have a large climate impact. To reduce this impact, cooling systems are increasingly shifting toward lower-GWP alternatives, including newer refrigerants such as hydrofluoroolefins (HFOs). From a carbon perspective, this transition is clearly beneficial, with carbon metrics showing a sharp reduction in climate forcing from refrigerant leakage.

However, evaluating refrigerant transitions solely through GHG metrics provides only a partial picture. Some low-GWP HFO refrigerants, such as HFO-1234yf and HFO-1234ze, decompose into trifluoroacetic acid (TFA), a highly persistent substance that accumulates in water systems over time.² While these effects fall outside the scope of carbon accounting, they form part of the broader environmental profile of refrigerant transitions. This example illustrates how climate-oriented measures can influence environmental considerations beyond GHG emissions.

2) Electrification and Material Intensity

Electrification is increasingly used as a decarbonisation strategy in the energy and transport sectors. From a carbon perspective, electrification presents a clear improvement. Renewable electricity and electric vehicles offer clear reductions in operational and lifecycle carbon emissions, benefits that are well reflected in carbon metrics. Delivering these reductions, however, requires substantial physical infrastructure. Batteries, renewable energy systems, and electricity networks depend on minerals such as lithium, cobalt, nickel, copper, and rare earth elements.³ Extracting and processing these materials can place pressure on land, water resources, and local environments, often far from where clean energy is used. Thus, from a broader environmental perspective, pressure shifts from fuel combustion to resource

extraction and material supply chains, impacts that are less visible in carbon-focused decision frameworks. This highlights how carbon-led transitions can redistribute, rather than eliminate, environmental pressures.

3) Bio-Based Fuels and Land Pressures

Bio-based fuels are often promoted as lower-carbon alternatives to fossil fuels. By using biological materials as energy sources, they aim to reduce reliance on oil, coal, and gas, and are frequently discussed as contributing to lower net emissions. Scaling up biofuel production, however, depends on land, water, and biological resources. Growing or collecting biomass can compete with food production, increase pressure on freshwater supplies, and alter natural ecosystems. In some cases, expanded biofuel use is associated with land-use change or biodiversity loss. Here, environmental pressure shifts from emissions to land and ecosystem impacts. Carbon metrics capture the emissions profile of the fuel itself, but do not account for how the fuel affects land and water resources. This illustrates how climate-focused decisions can leave important ecological trade-offs in the background.

Why This Matters Beyond Carbon Numbers

A reasonable question is why these trade-offs matter if carbon emissions are falling. After all, reducing emissions is the goal of climate action. The concern raised here is not that carbon reductions are unimportant, but that carbon numbers alone do not tell the full story of environmental impact. When environmental pressures are shifted rather than reduced, they eventually show up in everyday life. Water quality affects public health and ecosystems. Land-use change influences food prices, livelihoods, and biodiversity. Resource extraction shapes supply chains, costs, and geopolitical risks. These outcomes may not appear in carbon accounts, but they affect people and environments directly.

Carbon tunnel vision can also shape long-term decisions

in subtle ways. Policies and investments that look successful based on emissions metrics may lock systems into pathways that rely heavily on scarce resources or fragile ecosystems. Over time, this can make climate solutions harder to sustain, adjust, or scale. Perhaps most importantly, narrow optimisation can undermine trust. When actions presented as environmentally beneficial later reveal hidden environmental costs, public confidence in climate policy can weaken. Climate action that acknowledges trade-offs openly is more likely to earn long-term support than action framed around a single indicator. Recognising carbon tunnel vision does not mean slowing climate action. Rather, it encourages a more integrated perspective in which climate objectives are pursued alongside broader environmental considerations.

Concluding Remarks

Carbon metrics remain an essential component of climate action and play a central role in guiding policy and investment decisions. Expanding assessment beyond emissions, however, can provide a more comprehensive understanding of environmental implications when

climate strategies are evaluated. Carbon tunnel vision describes the tendency for strong emphasis on emissions performance to shape how options are compared. Recognising this tendency does not reduce the importance of decarbonisation. Rather, it highlights the value of considering how climate objectives interact with other environmental dimensions, including water, land, ecosystems, and resource use. An integrated perspective can support more informed decision-making, particularly where trade-offs are involved. Climate strategies that are assessed with awareness of these broader considerations are better positioned to remain effective and credible over time.

- 1 UNEP, *The Kigali Amendment to the Montreal Protocol: HFC Phase-Down*, (Paris: United Nations Environment Programme Ozone Action, 2016); IEA, "Electrification", Last updated July 11, 2023. <https://www.iea.org/energy-system/electricity/electrification>; IEA, "Biofuels", Last updated 2023. <https://www.iea.org/energy-system/low-emission-fuels/biofuels>.
- 2 Russell, M.H. *et al.*, "TFA from HFO-1234yf: Accumulation and Aquatic Risk in Terminal Water Bodies", *Environmental Toxicology and Chemistry* 31(9) (2012): 1957–1965.
- 3 IEA, *The Role of Critical Minerals in Clean Energy Transitions* (Paris: International Energy Agency, 2021), 1-5.

Short-Lived Climate Forcers: Tackling Climate Change Beyond Carbon Dioxide

Mr. HOY Zheng Xuan, ESI Research Associate and Dr. Shirleen LO Lee Yuen, ESI Research Fellow



Image by Gerd Altmann (geralt) from pixabay.com (Permission under Pixabay License)

Introduction

Climate change is driven primarily by carbon dioxide (CO₂), the main greenhouse gas (GHG) produced from burning fossil fuels and industrial processes. Once emitted, CO₂ accumulates in the atmosphere and remains there for centuries, which means that even large emission reductions may take decades to translate into noticeable climate improvements. Alongside CO₂, there are other climate pollutants known as short-lived climate forcers (SLCFs). In policy-oriented contexts, short-lived

climate pollutants (SLCPs) are often used to represent the warming subset of SLCFs targeted for mitigation. SLCFs are a diverse group of substances, some of which may contribute to global warming or global cooling, or may even affect human health. SLCFs that contribute to global warming typically have a much larger global warming potential (GWP) than CO₂ over the 20-year timeframe (GWP20). As their name suggests, SLCFs are short-lived compared with CO₂. This means their GWP is strongest over short timeframes, but decreases

when assessed over longer timeframes. For example, the 100-year GWP of 1 kg methane is 29.8 kgCO_{2-eq}, whereas the 20-year GWP is 82.5 kgCO_{2-eq}.¹ This combination of a high near-term warming influence and a short atmospheric lifetime presents an opportunity to slow the pace of near-term warming by reducing SLCF emissions. SLCFs are therefore increasingly discussed in climate policy, particularly because mitigation of certain pollutants, such as black carbon and ozone, can also deliver co-benefits for human health and air quality. This article explores what SLCFs are, why they matter within broader climate strategies, and how the reporting landscape for these pollutants is evolving.

What are SLCFs and Why Do They Matter?

SLCFs include substances such as methane (lifetime of around 12 years), tropospheric ozone (hours to weeks), hydrofluorocarbons (HFCs; days to years), and carbonaceous aerosols like black carbon (minutes to weeks). As summarised in Figure 1, the lifetimes of the substances range from minutes to about a decade, which is much shorter than that of CO₂. However, they can cause disproportionately large near-term warming through their effects on radiative forcing (RF). RF is a measure of how much a change in the atmosphere (like more GHG) will influence Earth's temperature by trapping more heat or letting more heat escape. Trapping more heat raises the surface temperature on Earth, whereas letting more heat escape lowers it. RF depends on how strongly a substance affects the Earth while it is present in the atmosphere, rather than on simply how long it lasts. In short, SLCFs influence short-term temperature changes more, while other GHGs such as CO₂ influence long-term warming. While the direct warming of some SLCFs is regionally concentrated, emissions worldwide

accumulate to produce measurable near-term global warming. According to the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6), over a 10–20-year period, the warming effect of SLCFs from a single year's emissions can be at least as large as that from the same year's CO₂ emissions.²

Meanwhile, the diverse range of lifetimes amongst SLCFs poses a challenge, requiring that mitigation strategies be tailored to each pollutant, as their lifetimes influence how quickly emission reductions translate into climate and air-quality benefits. Methane reductions can slow near-term warming within years, partly because methane is also a precursor to tropospheric ozone, which adds to warming. Aerosol reductions, including black carbon, can improve regional air quality quickly. These pollutants also have implications for human health, as black carbon and ozone can harm the respiratory and cardiovascular systems. Recognising these potential benefits has helped drive recent policy momentum, with initiatives such as the Climate and Clean Air Coalition (CCAC) and the Global Methane Pledge promoting targeted reductions. Moreover, given that SLCFs arise from diverse sources, spanning energy, transport, industry, agriculture, and waste, realising these benefits requires coordinated, cross-sectoral policies and integrated mitigation approaches. Achieving this in practice, however, depends on the ability to accurately quantify and track SLCF emissions, which remains a challenge.

Reporting Landscape of SLCFs

Currently, SLCFs are not fully integrated into national GHG inventory frameworks. Under the United Nations Framework Convention on Climate Change (UNFCCC), countries report the seven Kyoto Protocol gases in CO₂-equivalent units using standardised methodologies.

Figure 1. Key emission sources and atmospheric lifetimes of SLCFs with warming effect

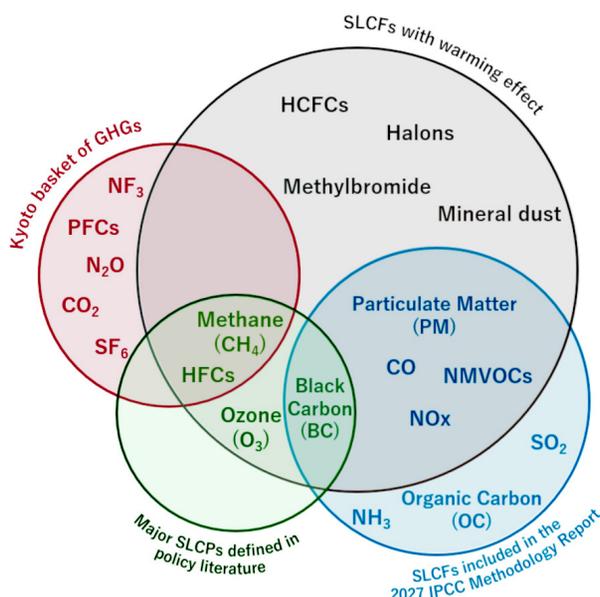
POLLUTANT	ANTHROPOGENIC SOURCES	LIFETIME
Methane (CH ₄)	 Enteric fermentation  Rice cultivation  Fossil extraction  Waste disposal	12 years
Tropospheric Ozone (O ₃)	Not directly emitted; formed in the atmosphere when anthropogenic emissions of CH ₄ , CO, NO _x , and NMVOCs react in sunlight.	Hours to weeks
Precursor Gases (e.g., NO _x , CO, NMVOCs)	 Vehicle exhaust  Industrial combustion  Solvent use  Biomass burning	Hours to months
Short-Lived Halogenated Species (e.g., HCFCs, HFCs, Halons, Methylbromide)	 Cooling systems  Fire suppression  Aerosol products	Days to years
Carbonaceous Aerosols (e.g., Black Carbon [BC])	 Diesel engines  Household burning  Open burning	Minutes to weeks
Mineral Dust	 Construction  Mining sites  Tillage dust	Minutes to weeks

Source: Authors' illustration based on data from IPCC (2021).³

However, most SLCFs cannot be expressed in the same units or governed by the same approaches because they interact chemically in the atmosphere, have short and variable lifetimes, and exert climate and air-quality impacts that are strongly regional rather than globally uniform. Recognising these challenges, the IPCC agreed at its 61st Session in 2024 to prepare a dedicated *2027 IPCC Methodology Report on Inventories for Short-Lived Climate Forcers*. This report will establish methods for quantifying anthropogenic emissions of specific SLCFs in mass units, reported annually at the national level. The report will cover species for which scientific understanding is sufficiently mature, including nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO₂), ammonia (NH₃), black carbon, organic carbon, and other primary particulate matter relevant for radiative forcing.

The coverage of species will target not only pollutants with a warming effect but also collective types of SLCFs including those with a cooling effect and those potentially impacting human health. The relationships among SLCFs, SLCPs, and the Kyoto basket of GHGs are shown in the Venn diagram in Figure 2. While SLCF is the term commonly used in the IPCC scientific framework, SLCP is more frequently used in policy-oriented contexts, particularly by initiatives such as the CCAC. The two terms overlap substantially but are not identical in scope. For example, tropospheric ozone is recognised as an SLCP in policy discussions due to its climate and air-quality impacts, but it is not included in the Kyoto basket of GHGs and is not directly reported in the *2027 IPCC Methodology Report*, because it is not emitted directly but formed in the atmosphere from precursor emissions (e.g., CH₄, CO, NO_x, and NMVOCs). Methane and halogenated gases regulated under the Montreal Protocol and Kigali Amendment will not be included, since established methodologies already exist for these species, such as those in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*.

Figure 2. Relationships among SLCFs, SLCPs, and the Kyoto basket of GHGs



Source: Authors' illustration based on data from IPCC (2021) and CCAC (2025).⁴

The report may also include a technical appendix on hydrogen, reflecting growing scientific interest in its indirect climate impacts. Although hydrogen itself is not a GHG, atmospheric hydrogen competes with methane for hydroxyl radicals (OH), which can lengthen methane's atmospheric lifetime and indirectly increase its warming effect. Recent literature suggests that the indirect effects of hydrogen emissions could translate to a non-negligible global warming potential, with some studies estimating values roughly in the range of 8–12 over a 100-year timeframe.⁵ These findings highlight the importance of improving the understanding and monitoring of hydrogen emissions.

The forthcoming guidelines will also address several long-standing obstacles in SLCF accounting. One difficulty is distinguishing anthropogenic from natural sources for pollutants such as aerosols and precursor gases, because both human activities and natural processes can emit similar particles in the same regions (e.g., fossil-fuel soot vs. wildfire smoke). For species like NMVOCs, chemical composition varies substantially across sectors, affecting ozone formation and complicating consistent reporting. Because many SLCFs have short atmospheric lifetimes and regionally concentrated effects, emissions need to be tracked with greater detail across locations and over time. The guidelines will also expand sector coverage to include all IPCC inventory sectors where the science is sufficiently robust to provide methodological guidance. Work on the methodology is expected to be finalised in 2027. The report will provide countries with a coherent, science-based framework for tracking SLCF emissions.

Concluding Remarks

Addressing SLCFs does not replace efforts to reduce long-lived GHGs, but it can provide complementary near-term climate benefits. Reducing SLCFs can help slow warming over the next decade, while certain pollutants (e.g., black carbon and ozone precursors) also influence air quality and ecosystem health. Integrating SLCF strategies into national climate plans can increase policy visibility, strengthen cross-sectoral collaboration, and build public support for ambitious climate action. As standardised reporting frameworks become available through the upcoming IPCC guidance, countries will be better equipped to track and implement SLCF mitigation in a more systematic and evidence-based manner.

- 1 IPCC, "The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity", In *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2021), 923–1054.
- 2 IPCC, "Short-Lived Climate Forcers", In *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2021), 817–922.
- 3 IPCC (2021). *Op. cit.*, 817–922.
- 4 IPCC (2021). *Op. cit.*, 817–922; CCAC, *Fact Sheet: Super Pollutants* (Climate and Clean Air Coalition, November 2025). <https://www.ccacoalition.org/content/short-lived-climate-pollutants>.
- 5 Rezaei, S. et al., "Global Warming Impacts of the Transition from Fossil Fuel Conversion and Infrastructure to Hydrogen", *Applied Energy* 397 (2025): 126363.

Digital Thirst: Why Southeast Asia Must Plan for Water-Smart Data Centres

Ms. Lalitha RAVI, ESI Research Associate



Image by Akela999 from pixabay.com (Permission under Pixabay License)

Introduction

Fresh water is one of the world's most limited resources. Only 3% of all water on Earth is freshwater, and just 0.5% is accessible for human use. As demand for digital services grows, data centre development is driving a sharp rise in electricity and water needs. With artificial intelligence (AI) workloads expanding rapidly, global water use by data centres is projected to jump from 560 billion litres a year in 2023 to 1.2 trillion litres by 2030.¹ As digitalisation deepens across Southeast Asia, rising water demand risks straining local supplies and competing with household, industrial, and agricultural needs. In regions facing water constraints, infrastructure limits, or climate-related pressures, unchecked growth can heighten operational, regulatory, and reputational risks for operators. This article examines how data centre growth in Southeast Asia drives water demand and interacts with environmental and infrastructure pressures, and why proactive planning is essential for water-smart digital infrastructure.

The Water Footprint of Data Centres

Understanding operational water use in data centres is essential for assessing its impact on local resources. Traditionally, most facilities rely on potable water for cooling, but growing demand is placing increasing pressure on freshwater resources and pushing operators to use non-potable and reclaimed water. Not all withdrawn water returns to the environment. Much of it is lost through evaporation. In hot and humid climates, evaporative cooling towers remain one of the most efficient heat-

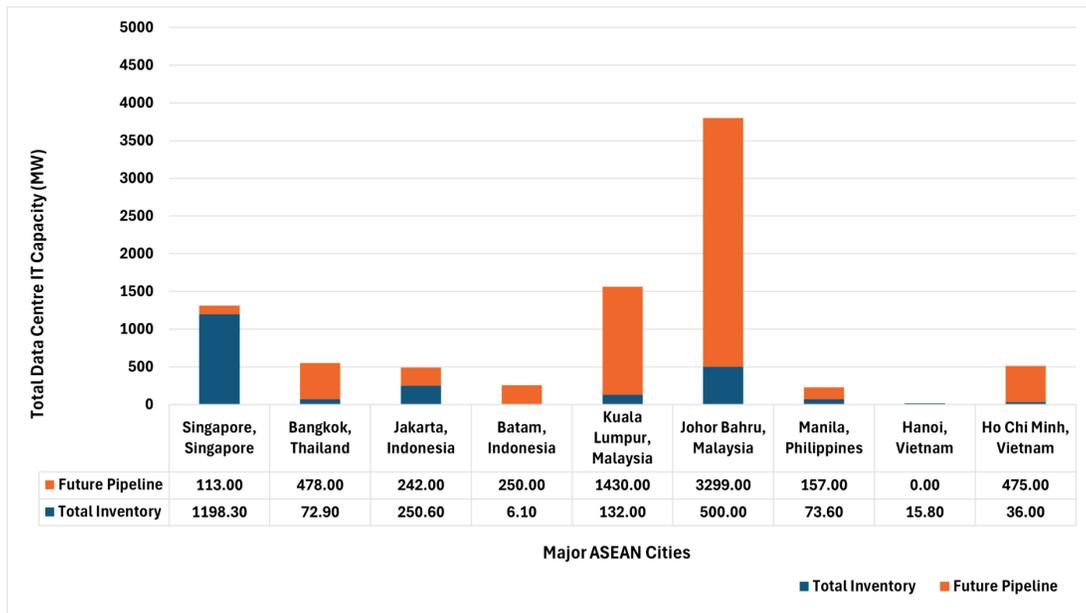
removal methods, given that they account for up to 97% of on-site water use.² Google's environmental disclosures indicate that its global portfolio of data centres collectively withdrew 37.3 billion litres of freshwater in 2024. Of this, nearly 80% of water was potable, and more than 29 billion litres were consumed.³ While Google has invested in water stewardship initiatives to offset this use, such measures are not yet widespread across the sector. To help operators measure efficiency, the industry uses the Water Usage Effectiveness (WUE) metric, developed by The Green Grid. WUE measures how many litres of water were consumed per kilowatt-hour of energy used. An ideal WUE is close to zero, but this is mostly possible only in cooler climates with air cooling. In Southeast Asia's tropical climate, WUE is generally higher.

Mapping Growing Water Demand Across ASEAN's Digital Hotspots

As ASEAN's digital economy expands, understanding how future data centre growth translates into water demand becomes critical. Using operational inventory and planned capacity of data centres as of 2025, the rapid rise in IT load across major ASEAN regional hubs is mapped in Figure 1. Johor Bahru stands out prominently, with a planned and under-construction capacity of 3,299 MW.

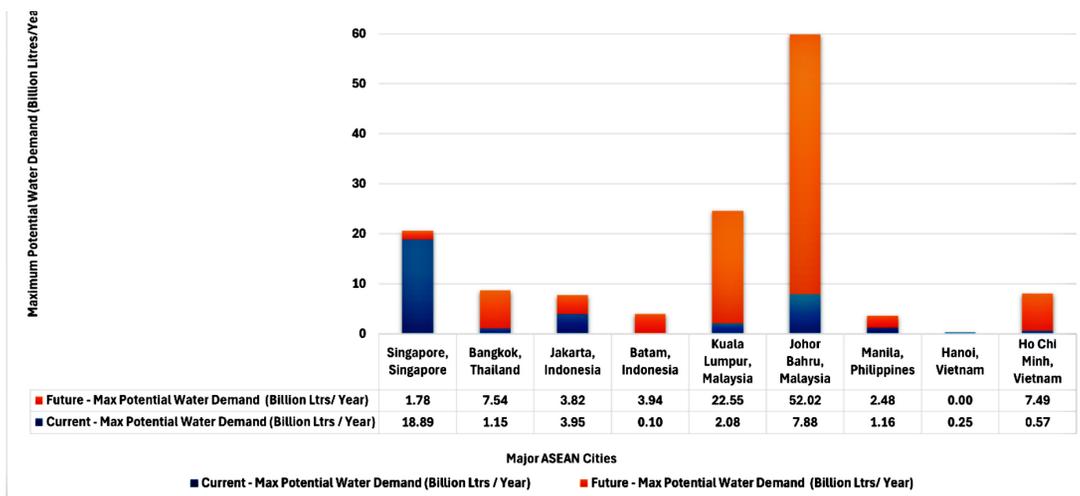
Without improvements in WUE, this rapid capacity expansion could significantly increase water demand. To illustrate the potential implications, the maximum theoretical cooling water demand associated with this expansion in each market is shown in Figure 2. The

Figure 1. Major ASEAN data centre markets: Current capacity vs future pipeline (MW)



Source: Author's illustration based on data from JLL (2025)⁴.

Figure 2. Maximum potential water demand of major ASEAN data centre markets (Billion litres/year)



Source: Author's estimation and illustration.

demand is estimated using today's industry average WUE of 1.8 L/kWh⁵ and applying a full-load, full-year scenario (8,760 hours). Although data centres rarely operate continuously at rated load, upper-bound estimates help stress-test local water systems. Under this scenario, potential water demand rises sharply across the region, with Johor Bahru's upper-bound approaching 60 billion litres annually if all planned capacity were to be built and operated at rated load.

Regulations to Manage Water Consumption of Data Centres: Johor Bahru and Singapore

Given the scale of expansion, Johor Bahru is emerging as one of ASEAN's fastest-growing data centre hubs, making its water landscape critical. Malaysia relies

heavily on rainfall to support domestic water use, with about 97% of the national water supply sourced from rain-fed rivers and reservoirs that are replenished during the rainy season. This reliance exposes the system to seasonal variability, droughts, and climate-related stresses. In response to drought conditions and mounting pressure on Johor Bahru's water supplies, authorities have issued an 18-month temporary deferral on water-cooled data centre expansion projects. In addition to natural phenomena, localised disruptions can also affect water supply reliability. For example, in October 2025, a pollution incident along Sungai Johor forced several water treatment plants to halt operations, affecting nearly 800,000 residents. Data centres depend on continuous water for cooling; such disruptions pose operational risks and increased competition with other users. Recognising this, the Johor Bahru government has refined its approval framework to prioritise water-efficient data centres.

Water security has been a critical national concern for Singapore due to its limited natural freshwater resources. The country consumes 440 million gallons of water per day, and this use is projected to double by 2065, making water management critical. For large data centres, Singapore has reported an average WUE of 2.2 m³/MWh and is working with operators to achieve 2.0 m³/MWh over the next decade.⁶ Under the Tropical Data Centre standard in Singapore, facilities are permitted to run at higher operating temperatures up to 35°C to reduce cooling energy demand by around 2 to 5% for every 1°C increase. In parallel, approvals for new facilities under the Green Data Centre Roadmap are tightly controlled, prioritising projects that demonstrate high standards of energy and water efficiency to manage growing demand. Existing facilities are required to track and report annual water use and submit Water Efficiency Plans, creating visibility into how water is used over time. This is complemented by government co-funding through the Water Efficiency Fund, which supports investments in water-efficient systems and recycling. Taken together, these approaches reflect an ongoing effort to manage rising digital demand without placing additional stress on limited water resources.

Emerging Pathways for Water-Smart Data Centres

As data centre industry grows, cooling will remain one of the largest drivers of onsite water use. New cooling technologies are emerging to reduce water stress. Two of the most significant developments are direct-to-chip liquid cooling and immersion cooling. Direct-to-chip systems circulate coolant through cold plates attached to processors, while immersion cooling submerges entire servers in specialised non-conductive fluid. Both approaches sharply reduce water use by avoiding evaporative cooling and offer more targeted, efficient heat removal, like shifting from flood irrigation to drip irrigation in agriculture. Microsoft has deployed closed-loop, chip-level liquid cooling that enables servers to run reliably at higher temperatures without evaporative cooling and announced that its Southeast Asia cloud region in Johor Bahru will achieve zero-water evaporation for cooling by using this approach.

Alongside next-generation solutions, operators are exploring technologies that improve water efficiency within traditional cooling towers. In Singapore, Amazon Web Services (AWS) and Hydroleap installed electro-oxidation systems that increase Cycles of Concentration and enhance water circularity, thereby reducing the volume of fresh make-up water required. In Malaysia, Air Trunk and Johor Special Water (JSW) are developing a major recycled-water supply for non-potable cooling, while ST Telemedia in Thailand is exploring the use of cold energy from LNG regasification as an alternative cooling source.⁷ Together, these innovations reflect a shift from optimising evaporative systems to redesigning cooling. Planning for water-smart data centres, therefore, requires matching the cooling approach to the region's constraints and infrastructure readiness.

Concluding Remarks

As Southeast Asia deepens its digital transition, data centres will form a critical part of the region's economic and social infrastructure. However, sustaining this growth depends on stable and predictable access to energy and water resources. Therefore, planning water-smart data centres requires a holistic approach spanning hydrology, urban planning, and technology adoption. Reclaimed water use, closed-loop cooling, desalination, and digital optimisation all offer pathways for reducing dependence on freshwater sources. Singapore's long-standing approach to industrial water management and Johor Bahru's recent policy shifts demonstrate how governance frameworks can shape more sustainable digital ecosystems. Taking these steps now will strengthen not only the region's digital competitiveness but also the security and sustainability of its water systems.

- 1 IEA, *Energy and AI* (Paris: International Energy Agency, 2025), 242-243.
- 2 IMDA, *Green Data Centre Roadmap* (Singapore: Infocomm Media Development Authority, 2025), 16.
- 3 Google, *2025 Environmental Report* (Mountain View, CA: Google LLC, 2025), 110-111.
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Beyond Concrete and Steel - Understanding Waste from Building Wiring and Piping Systems

Mr. Christian Allen E. JIMENEZ, ESI Research Assistant



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Introduction

The built environment is one of the most material- and emission-intensive sectors. It represented approximately 32% of global energy used and 34% of carbon dioxide (CO₂) emissions,¹ and construction consumes over half of extracted raw materials. Although much of the material is embedded in long-lived assets such as buildings and infrastructure, discussions of construction and demolition waste continue to focus primarily on structural materials such as concrete and steel.

This emphasis obscures a substantial and recurring waste stream generated by Mechanical, Electrical, and Plumbing (MEP) systems. Electrical wiring and piping are deeply embedded within the building fabric, yet they are rarely designed to last for the full service life of the structure. Instead, they are typically replaced at a system-wide scale, often independently of structural renewal, creating repeated cycles of material removal and replacement. Wiring and piping systems generally have service lives of 20–25 years. Electrical cables may no longer comply with updated safety standards or increasing load requirements, while pipes deteriorate due to corrosion, leakage, or layout changes. As a result, rewiring and re-piping frequently occur even when the building structure itself remains serviceable. This dynamic

is particularly relevant in Singapore, where more than half of the building stock is older than 26 years and many buildings are approaching major system upgrades to meet current safety, performance, and energy-efficiency requirements.

Rapid redevelopment cycles further intensify the removal of these systems. Beyond individual buildings, wiring and piping form part of broader urban utility networks. Their renewal is often coordinated with redevelopment or upgrading initiatives, such as the Urban Redevelopment Authority (URA)'s CBD Incentive Scheme, supported by planning policies and incentives that encourage comprehensive retrofits. In addition, shifts towards centralised infrastructure models, such as district cooling, can require partial or full replacement of existing pipes and cables, further increasing recurring material flows.

Taken together, short component lifespans, policy-driven redevelopment, and evolving urban utility models make wiring and piping a persistent yet under-recognised source of construction waste. Unlike major structural materials, however, their post-removal pathways remain poorly understood. This raises a central question that motivates this study: what happens to wires and pipes once they are removed from buildings?

Material-Specific End-of-Life Pathways for Pipes and Wires

Understanding how pipes and cables are constructed is essential because material composition directly shapes recyclability and end-of-life outcomes. While metals such as copper, aluminium, and steel form the core of most wires and many pipes and benefit from mature, high-efficiency recycling, plastics dominate cable sheathing and some piping applications and present far greater challenges. Plastic piping systems are subject to standards that define performance requirements, including mechanical strength, pressure ratings, temperature resistance, and chemical stability (e.g., ISO 4427 and ISO 161 for polyethylene). These standards constrain polymer selection and additive use to meet durability, fire safety, and insulation requirements, ensuring long-term service but complicating recycling.

Common plastics include polyvinyl chloride (PVC; rigid, corrosion- and load-resistant) and high-density polyethylene (HDPE; tough and flexible), often modified with plasticisers, stabilisers, flame retardants, fillers, or copolymers to meet standardised performance criteria economically and safely. Such formulations create heterogeneity in polymer chemistry and multi-material configurations that hinder separation, identification, and remelting during recycling. In practice, product design prioritises in-use performance over end-of-life recovery: standards rarely require material labelling, recyclability thresholds, or disassembly considerations, and allow

inseparable assemblies where they improve function. Electrical cables and construction products exemplify this logic, with complex layering driven by fire, insulation, and mechanical protection requirements.

Observed recycling rates for common plastics illustrate these challenges. Only around 9% of plastic waste is recycled globally,² with higher recycling rates for PET and HDPE. For example, of the bottles collected in the United States in 2022, approximately 96.5% of polyethylene terephthalate (PET) and 98.4% of HDPE bottles are recycled.³ These figures are not representative of plastics used in building systems. Plastics in piping and electrical wiring are typically compounded with performance-enhancing additives to meet durability and safety requirements. While such additives improve in-use performance, they reduce material homogeneity and complicate reprocessing. Mechanical recycling generally requires relatively consistent polymer streams; additive-rich formulations limit compatibility with standard recycled streams and reduce material quality. Consequently, plastics from wiring and piping systems often exhibit limited recyclability and are more frequently directed toward energy recovery or disposal rather than closed-loop material recycling.

Given that plastics in pipes and cables are often mixed at granular and molecular levels through polymer blends, additives, and cross-linked structures, conventional recycling faces inherent limitations. Advanced technologies, mechanical or chemical, can

Table 1. Overview of plastic recycling technologies

Technology category	Plastics treated	Indicative recovery/yield	Key constraints	Remarks
Conventional mechanical recycling	Clean, single-polymer thermoplastics (e.g. PET, HDPE, LDPE)	Approx. 70 - 85% process yield under ideal conditions	Requires homogeneous, uncontaminated input; unsuitable for PVC, XLPE, PEX, or additive-rich plastics	High technical efficiency at process level, but limited applicability to construction plastics
Mechanical recycling – Observed real world system performance	Primarily PET and HDPE	PET: approx. 20 - 25%; HDPE: approx. 10 - 30%; most others: <5%	Sorting losses, contamination, economic viability, and market demand constrain recovery	Reflects end-to-end system outcomes rather than laboratory yields
Chemical recycling (steam cracking)	Mixed and contaminated plastics, including cable residues	Produces chemical intermediates (e.g. ethylene, propylene, aromatics); low direct polymer recovery	High energy demand; outputs are feedstocks, not finished polymers; chlorine management required	Enables treatment of otherwise unrecyclable plastics but offers limited material circularity
Catalytic cascade depolymerisation	Targeted polymers (e.g. PVC)	High conversion reported at lab scale (up to approx. 90 wt%)	Limited to pilot or laboratory scale; no commercial deployment	Demonstrates technical potential, but not yet a viable waste-management pathway

Source: author's summary based on multiple sources⁴

partially address heterogeneity, but achievable recovery yields, material circularity, and technological maturity remain limited when applied to complex construction plastics. Table 1 summarises how recycling technologies differ markedly in achievable recovery yields, material circularity, and technological maturity.

Taken together, the technologies reviewed reveal a structural mismatch between the material characteristics of plastic pipes and cable systems and the requirements of effective recycling. Mechanical recycling performs well only for clean, single-polymer streams. These conditions rarely apply to piping and wiring plastics, which are formulated with additives, fillers, and cross-linked structures to meet durability, fire safety, and insulation requirements. Chemical recycling expands the range of treatable materials by operating at the molecular level. However, it typically converts polymers into lower-value chemical intermediates rather than enabling closed-loop recovery into new pipes or cables. As a result, while multiple recycling pathways exist in principle, none reliably deliver high-yield, equivalent-quality recycling for plastic components used in building services.

Why Recycling Outcomes Remain Low for Pipes and Cables

Recycling outcomes for piping and wiring plastics are constrained by material degradation, system-level limitations, and economic factors. Unlike metals, plastics degrade during reprocessing: thermal exposure shortens polymer chains, leading to reduced strength, increased brittleness, and inferior insulation performance. For pipes and cables, which must comply with strict safety and performance standards, this degradation effectively precludes reuse in equivalent applications, resulting in systematic downcycling, system performance further limits recovery. Plastic pipes and cable sheaths are often embedded within building assemblies, exposed to contamination, and composed of visually similar or additive-rich polymers that challenge optical sorting. This sensitivity is reflected in international waste trade standards, where contamination thresholds as low as 0.5% have been applied to post-consumer plastics in China, effectively excluding mixed waste streams. Such

requirements underscore the difficulty of recycling plastics recovered from construction and demolition activities.

Virgin polymers offer predictable quality and, in many markets such as the United States, cost advantages due to oversupply and established production scale, whereas recycled plastics, especially those from complex sources like pipes and cables, require extensive sorting, cleaning, and testing, yet still exhibit variable properties that complicate performance reliability and raise liability concerns. Chemical recycling, while technically capable of treating mixed and contaminated plastics, is energy-intensive, often yields fuels rather than new polymers, and remains dependent on subsidies or guaranteed offtake.

Conclusion

Plastic piping and wiring systems rarely achieve high-quality recycling due to short service lives, design-driven material heterogeneity, and technical, economic, and regulatory constraints. Reuse is generally impractical, while mechanical and chemical recycling mostly downcycle materials or recover energy rather than produce new components. As a result, decommissioned pipes and cables are largely disposed of, creating a persistent waste stream during building retrofits and renovations. This highlights a structural mismatch in building services design: systems are optimised for in-use performance but poorly aligned with end-of-life recovery, underscoring the need to explicitly account for these material flows to identify design, policy, and technological interventions that improve circularity.

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Beyond Carbon Accounting: Why the GHG Protocol Now Needs a Circular Economy Companion

Mr. Alvin EE Wei Liang, ESI Research Fellow

Introduction

The Greenhouse Gas (GHG) Protocol has become the dominant framework for corporate climate accounting, providing organisations with a structured way to quantify emissions across operations and value chains. Through the familiar Scope 1, Scope 2 and Scope 3 structure, it has enabled emissions to be integrated into corporate governance, regulatory disclosure and investment decision-making.

As climate accounting has matured, its limitations have become more apparent. Global material extraction, throughput and waste generation continue to rise, even as emissions reporting improves. Although many environmental pressures, framed primarily as climate challenges, are closely linked to how materials are produced, used and recovered, these dimensions remain only partially captured by emissions-based accounting frameworks. At the same time, circular economy principles have gained traction across industry and policy



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communities, supported by growing standardisation efforts and measurement methodologies. The challenge now lies not in defining circularity or measuring individual indicators, but in translating material flow insights into reporting structures that are comparable, credible and decision-relevant. How circular economy performance is accounted for, disclosed and interpreted will increasingly shape how organisations understand risk, resilience and long-term sustainability beyond carbon alone.

Circular Economy Implementation and Measurement

So far, circular economy efforts have been largely focused on principles, strategies and measurement tools. Conceptual work by the Ellen MacArthur Foundation in 2015 established the core ideas of designing out waste, keeping materials in use and regenerating natural systems. Subsequent frameworks, including earlier versions of the Circular Transition Indicators developed by the World Business Council for Sustainable Development, enabled companies to quantify material inflows, outflows and recovery rates. More recently, the publication of the ISO 59000 family of standards in 2024 has formalised circular economy implementation. For example, ISO 59004 establishes common terminology and system principles, ISO 59010 provides guidance on circular business models and value networks, and ISO 59020 sets out methods for measuring and assessing circularity performance. Together, these standards offer international consensus on how circular economy practices can be implemented and measured in a robust and auditable manner.

However, neither conceptual frameworks nor ISO standards were designed primarily as corporate reporting protocols. While they support internal assessment, management systems and implementation, they do not prescribe how circularity information should be structured, aggregated and disclosed for external reporting. As a result, circularity metrics have remained fragmented, selectively reported and difficult to compare across organisations and sectors.

The Role and Framework of Global Circularity Protocol (GCP)

The GCP for Business,¹ launched in November 2025, addresses this missing layer. Developed by the World Business Council for Sustainable Development in partnership with the UNEP-hosted One Planet Network, the GCP is explicitly designed to support consistent, transparent and comparable reporting of circular economy performance at the organisational level. In this respect, the GCP plays a critical role in circularity that corresponds to the role played by the GHG Protocol for emissions. It does not redefine circular economy principles, nor does it replace ISO 59000. Instead, it provides a reporting architecture that enables the organisation, interpretation, and communication of circularity data, often generated using ISO-aligned methods, in ways that support governance, accountability and performance improvement. By shifting the focus from measurement alone to structured reporting, the GCP seeks to embed circular economy considerations within mainstream corporate decision-making, in much the same way that carbon accounting has evolved over the past two decades.

Central to the GCP is a scope-based structure that brings clarity to system boundaries and responsibility for circular economy impacts.

- **Scope A** captures material exchanges between an organisation and the natural environment. This includes the extraction of biomass, metals, minerals and other resources used as inputs, as well as waste and emissions released back into environmental systems. Scope A, therefore, reflects the organisation's direct interaction with natural resource stocks and sinks.
- **Scope B** focuses on material flows within organisational boundaries. It examines how materials enter the organisation, how they are transformed into products and services, how long they remain in use, and how much value is retained or lost through inefficiencies, waste or low-value recovery.
- **Scope C** extends across the value chain, capturing upstream and downstream circularity impacts associated with suppliers, customers, use-phase behaviour and end-of-life treatment. In practice, Scope C addresses many of the same boundary challenges that companies already encounter when accounting for Scope 3 emissions.
- **Scope D** addresses system-level enabling effects. It recognises that some circular actions generate benefits beyond a single organisation or value chain, such as shared infrastructure, interoperable standards, digital platforms or business models that enable higher utilisation across multiple actors.

Together, these scopes provide a comprehensive yet structured way to understand how materials flow through and beyond an organisation, and how circular strategies interact with environmental and economic systems.

Relationship with GHG Protocol

The relationship between the GCP and the existing GHG Protocol is explicitly complementary. GHG Protocol Scopes 1 and 2 broadly align with GCP Scopes A and B, where emissions and material flows arise from direct operations and purchased inputs. GHG Protocol Scope 3 aligns closely with GCP Scope C, where impacts occur across complex value chains beyond direct control. The introduction of GCP Scope D provides a structured context for revisiting discussions around Scope 4 in GHG accounting, which covers avoided emissions and system-level effects.² It was devised as a voluntary metric in 2013, but has never been formally adopted due to concerns over attribution, double counting and methodological robustness. By anchoring system-level contributions in material flows and circular outcomes rather than emissions alone, the GCP offers a more disciplined way to recognise enabling effects without undermining the integrity of emissions inventories.

Potential Challenges

As with Scope 3 emissions accounting, circularity reporting under the GCP faces significant data challenges. Material flows across value chains are often fragmented, poorly documented and dependent on supplier disclosure.

Data quality and availability are therefore likely to vary considerably during the early stages of adoption. However, experience with Scope 3 suggests that imperfect data should not be viewed as a barrier to progress. The introduction of reporting requirements itself creates incentives for improved data governance, supplier engagement and methodological refinement over time. The GCP explicitly encourages transparency around assumptions, limitations and improvement pathways, recognising that circularity reporting will mature through iterative reporting cycles.

Improving Performance through Reporting

The significance of the GCP lies not only in measurement, but in how reporting influences organisational behaviour. Consistent disclosure makes circularity visible to management, boards, investors, and business partners, supporting integration into product design, procurement strategies and capital investment decisions. Reporting also enables benchmarking and peer comparison, which have proven to be powerful drivers of improvement in emissions management. As circularity data becomes more standardised, organisations are better able to assess performance relative to peers and to identify where circular strategies can deliver the greatest value. In this sense, the GCP aims to replicate the positive impact observed in carbon accounting. Measurement enables reporting. Reporting enables scrutiny. Scrutiny drives performance improvement.

Conclusion

The GHG Protocol has reshaped how organisations measure and manage GHG emissions, while the ISO 59000 family of standards has strengthened the implementation and measurement of circular economy practices. Yet until recently, circularity lacked a comparable reporting framework to support transparency, comparability, and governance at the organisational level. The GCP for Business addresses this gap by providing a structured reporting architecture that complements existing carbon and circular economy frameworks. By aligning circularity measurement with a clear scope-based reporting structure, the GCP enables organisations to better integrate material flows, resource use and system-level effects into mainstream decision-making. As sustainability reporting continues to evolve beyond carbon alone, the GCP represents an important step toward a more coherent and actionable sustainability reporting landscape.

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Staff Publications

Internationally Refereed Journal Articles

Yu Chen, **Bin Su**, Kangjuan Lv, and Siwei Zhu, “Heterogenous Strategy and Performance Decomposition of Regional Industries in China: From the Perspective of Resource Misallocation”, *Natural Resources Forum* 50(1) (2026): 204-224. <https://doi.org/10.1111/1477-8947.12568>.

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Jonathan T.E. Lee, Muhammad Usman Khan, Jingxin Zhang, **Kendra H.Y. Ho**, **Shee Jia Chew**, **Alvin W.L. Ee**, Jie Bu, Yong Wei Tiong, Xiangzhou Yuan, Yong Sik Ok, Birgitte K. Ahring, and Yen Wah Tong, “Cellulose-Based Bioplastic Replacement of Single Use Plastic Bags in the Collection and Treatment of Food Waste via

Anaerobic Digestion for a Zero-Waste Circular Economy”, *Chemical Engineering Journal* (2025): 170933. <https://doi.org/10.1016/j.cej.2025.170933>.

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David C. Broadstock, **Roger Fouquet**, and **Jeong Won Kim**, “Carbon Pricing and Stock Performance: Are Carbon Prices Already More Influential than Energy Prices?”, *Energy Policy* 206 (2025): 114775. <https://doi.org/10.1016/j.enpol.2025.114775>.

Hongyan Li, Haoming Liu, Alberto Salvo, and Rhita Simorangkir. “Heat Impacts College Student Grades Even in Rich Singapore”, *Journal of Economic Behavior & Organization* 239 (2025): 107244. <https://doi.org/10.1016/j.jebo.2025.107244>.

Staff Presentations and Moderating

29 January Roger Fouquet presented “Historical Lessons for Achieving and Accelerating Net-Zero Transitions: Energy Innovation, Industrial Clusters and the Role of the State” via online at the *Oxford Review of Economic Policy Special Issue on The Economics of Net Zero*. Oxford, UK.

20 January Sita Rahmani delivered a guest lecture on “Global Dynamics of the Solar Photovoltaics Supply Chain” for *International Political Economy (MSc programme)*, a course offered by S. Rajaratnam School of International Studies (RSIS), Nanyang Technological University (NTU), Singapore.

19 January Kendra Ho presented “Critical Minerals for the Energy Transition” at the *Clean Energy and Transition Policy Workshop*, organised by 1.5Degrees, Singapore.

17 January Yao Lixia presented “Path to Energy Transition: Carbon Lock-In in Northeast Asia” at the *International Conference on Environmental Science and Sustainability*, organised by University of Technology Sydney, University of Tasmania and University of Melbourne, Sydney, Australia.

16 January Kim Jeong Won presented “Carbon Pricing and Market Discussions at COP30” at the *7th ESI Workshop on Carbon Pricing*, organised by ESI, Singapore.

16 January Kim Jeong Won moderated “Panel Discussion: The Future of Carbon Pricing” session at the *7th ESI Workshop on Carbon Pricing*, organised by ESI, Singapore.

16 January Li Hongyan moderated “Article 6 and Carbon Markets” session at the *7th ESI Workshop on Carbon Pricing*, organised by ESI, Singapore.

19 December Joydeep Ghosh presented “Carbon Border Adjustment Mechanism (CBAM) and Burden Sharing: A CGE Modelling Approach” at the *Vietnam Symposium in Climate Transition 2025*, organised by the Association of Vietnamese Scientists and Experts, the University of Da Nang and Massey University, Da Nang, Vietnam.

11 December Yao Lixia was a panellist in “How Can We Build a New Paradigm for Efficient International Cooperation in Green Energy?” session at the *Green*

Energy International Cooperation and Development Forum, organised by Yangjiang Green Energy Technology Research Institute, Yangjiang, China.

4 December Sung Jinseok presented “Expanding Role of Natural Gas: Opportunities and Challenges” at the *ESI Workshop on Natural Gas: Gas Market Dynamics, Uncertainties, and the Changing Landscape*, organised by ESI, Singapore.

30 November Sita Rahmani presented “Decarbonising the Digital Backbone: Unbundled Renewable Energy Certificates (RECs) Procurement in Data Centre Operators” at the *3rd International Society for Energy Transition Studies (ISETS) International Conference*, organised by the University of Tokyo, Tokyo, Japan.

30 November Yao Lixia was a panellist in “China Shock or Green Opportunity? The Global South and China’s Clean-Tech Go-Overseas” session at the *3rd ISETS International Conference*, organised by the University of Tokyo, Tokyo, Japan.

30 November Yao Lixia moderated “Energy Development Planning” session at the *3rd ISETS International Conference*, organised by the University of Tokyo, Tokyo, Japan.

28 November Roger Fouquet presented “Long Run Perspectives on Energy and Climate Change” at a *Lecture Series of the Department of Public Administration, National Chengchi University*, Taipei, Taiwan.

25 November Angel Mah presented “Introduction of ESI’s Hydrogen Work and Workshop Objectives” at the *Hydrogen Economy: Current Landscape, Opportunities, Challenges, and the Way Forward Workshop*, organised by ESI, Singapore.

24 November Kim Jeong Won was a panellist at the *Symposium on International Cooperation on Carbon Markets Toward Carbon Neutrality in ASEAN and Japan*, organised by the Society for Environmental Economics and Policy Studies (SEEPS) and Economic Research Institute for ASEAN and East Asia (ERIA), Jakarta, Indonesia.

24 November Sita Rahmani presented “Confronting Climate Disruption in the mid-21st Century: Southeast Asian Socio-ecological Governance from Within” at the *49th Southeast Asia Seminar: Global Disruptions and Southeast Asia - Exploring Histories, Narratives, and Transdisciplinary Challenges*, organised by the Center for Southeast Asian Studies (CSEAS), Kyoto University, Phnom Penh, Cambodia.

17 November Alvin Ee was a panellist discussing “Circularity in Tech Supply Chains: Aligning Sustainable Solutions in Singapore and Beyond” at the *Global Trade and Distribution Council (GTDC) Sustainability Summit 2025*, organised by GTDC, Singapore.

13 November Ng Zu Xiang presented “Is the EU Turning Back on Their Climate Commitments?” at the *ESI Workshop on Decarbonisation Policies Around the World: Lessons, Gaps, and Opportunities*, organised by ESI, Singapore.

13 November Wannaphaluk Tonprasong presented “The Great Reversal: Policy, Power and Geopolitics in the US” at the *ESI Workshop on Decarbonisation Policies Around the World: Lessons, Gaps, and Opportunities*, organised by ESI, Singapore.

9 November Li Hongyan presented “Empirical Assessment of the Impact of Carbon Pricing Mechanism: Global Evidence” at the *2nd Asian Conference on Environmental Economics and Policy*, Fukuoka, Japan.

Staff Media Contributions

Alvin Ee was quoted in “网购自用家电将严管 环境局拟7月起提高节能要求”, *联合早报*, *Lianhe Zaobao*, 26 January 2026. See <https://www.zaobao.com.sg/news/singapore/story20260126-8112289>.

Chew Shee Jia was interviewed in *Channel 8 News Tonight (TV)* on emission factors and emission calculator for cloud services, 22 January 2026. See <https://www.8world.com/singapore/imda-digital-sustainability-3029986>.

Alvin Ee was quoted in “IMDA’s New Initiatives to Build SME Capacities to Be Tech-Savvy and Green”, *GovInsider*, 22 January 2026. See <https://govinsider.asia/intl-en/article/imdas-new-initiatives-to-build-sme-capacities-to-be-tech-savvy-and-green>.

Alvin Ee was quoted in “Electric or Gas, Instant or Storage: Which Water Heater Is Right for Your Home?”, *The Straits Times*, 17 November 2025. See <https://www.straitstimes.com/singapore/environment/electric-or-gas-instant-or-storage-which-water-heater-is-right-for-your-home>.

Kim Jeong Won was quoted in “ST Explains: Why Are Renewables Not Easy to Talk about at UN Climate Summits?”, *The Straits Times*, 3 November 2025. See <https://www.straitstimes.com/singapore/environment/st-explains-why-are-renewables-not-easy-to-talk-about-at-un-climate-summits>.

Recent Events

13-14 November, ESI Workshop on Decarbonisation Policies Around the World



Photo by ESI staff

On November 13–14th, ESI hosted a closed-door research workshop at Orchard Rendezvous Hotel on “Decarbonisation Policies Around the World: Lessons, Gaps, and Opportunities”, bringing together 23 participants from Singapore and abroad. In line with the workshop’s goal of navigating an increasingly complex and fast-shifting global decarbonisation landscape, speakers presented country case studies, regional comparisons, sector-specific transition challenges, and emerging governance innovations across the energy, industry, finance, and trade domains.

Day 1 of the workshop began with an overview of how Australia, the US, and the EU are navigating

decarbonisation amid political shifts, supply-chain tensions, and industrial competitiveness concerns, followed by an afternoon that moved from sectoral transition pathways to the legal, financial, and energy dilemmas shaping future climate action. Discussions underscored the accelerating but uneven pace of policy tightening, the scale of infrastructure needs, and the political sensitivities surrounding energy prices and technology choices. Meanwhile, discussions highlighted the sweeping reversals of U.S. climate and industrial policies under Trump 2.0, the surge of green industrial policies worldwide and their clashes with WTO rules, and how central banks are reassessing financial stability, price risks, and green finance in a world of climate shocks and geopolitical competition.

Day 2 discussed the implications of a second Trump administration for global climate action, highlighting that intensifying U.S.–China rivalry is straining global cooperation even as Korea’s net-zero strategy shows how major economies continue advancing clean-energy transitions despite geopolitical tensions. In the concluding roundtable discussion, speakers emphasised how stranded-asset risks, wavering trust in policy instruments, and the challenge of shifting demand complicate decarbonisation, while underscoring China’s role as a vital driver of cheap renewables. Across both days, predictable policies, cross-sector and regional coordination, and long-term investment signals are essential to maintain momentum in an increasingly complex and uncertain world.

25-26 November, ESI Workshop on Hydrogen Economy



Photo by ESI staff

On 25–26 November, ESI hosted a closed-door workshop at Orchard Rendezvous Hotel on “Hydrogen Economy: Current Landscape, Opportunities, Challenges, and the Way Forward”, bringing together 32 participants from Singapore and abroad. The workshop aimed to deepen understanding of the global hydrogen landscape and to identify the key actions required to move it forward. The workshop began with an overview

of recent developments and market trends, covering project progress, global supply and demand dynamics, and challenges in upscaling them. This was followed by a session on technical and safety issues along the hydrogen supply chain and the mitigation measures required. The final session examined the role of policy in shaping the hydrogen economy, drawing on strategies implemented across various jurisdictions. During

roundtable discussions, participants exchanged insights on key barriers to implementing a hydrogen economy, potential offtake sectors, and policy measures to support hydrogen development.

3-4 December, ESI Workshop on Natural Gas

On 3–4 December, ESI hosted a closed-door workshop at the Hotel Grand Copthorne Waterfront on Gas Market Dynamics, Uncertainties, and the Changing Landscape, bringing together speakers and participants from Singapore and abroad to explore the evolving market landscape, risks, and uncertainties shaping international gas markets. The workshop explored how global and regional gas markets are navigating volatility amid ongoing market restructurings. Key topics included energy security and demand-supply trajectories, as well as international market trends, environmental implications,



Photo by ESI staff

and geopolitical risks. The participants also discussed growing uncertainties around evolving regulations, challenges in the natural gas market, and the role of natural gas in the ongoing energy transition.

16 January, 7th ESI Workshop on Carbon Pricing



Photo by ESI staff

ESI hosted its 7th Workshop on Carbon Pricing with the theme of Carbon Pricing at COP30 and Its Implications on 16th January 2026. The workshop began with remarks from Prof. Lee Poh Seng, ESI Executive Director, to welcome around 70 attendees, including 7 overseas speakers from Argentina, Belgium, Germany, Japan, South Korea, and the United States. In the first session, speakers introduced the European Union's carbon border adjustment mechanism (CBAM) and why CBAM was a hot issue at COP30. They explained the potential conflict surrounding CBAM implementation, and examined other countries' political responses and strategies to deal with CBAM. The second session focused on Article 6 of the Paris Agreement and the development of global carbon markets. Speakers provided a clear overview of Article 6 implementation status and discussed the growth and challenges of carbon credit projects. In the following panel discussion, participants explored key carbon pricing topics that will likely be addressed at upcoming COP31 and shared their insights on the linkage between CBAM and carbon markets, the environmental integrity of carbon



Photo by ESI staff

credits, and the implications of multilateral joint initiatives to promote carbon markets. They also highlighted the importance of clear guidelines for carbon credits and of establishing a proper, robust monitoring, reporting, and verification (MRV) framework.

New Staff

LIANG Zhuang
Research Fellow



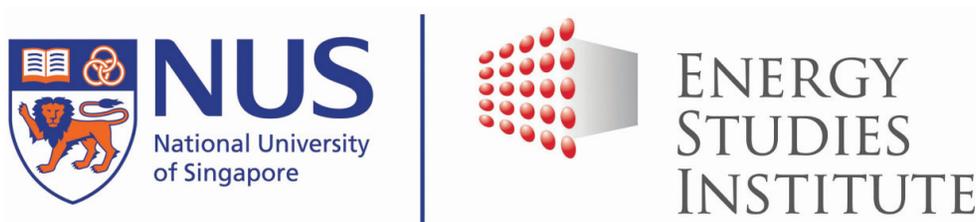
Dr. Liang Zhuang joined ESI as a Research Fellow in November 2025. He received his PhD from Beihang University in November 2025. His research primarily focuses on energy economics, low-carbon power system transitions, and the residential load management. He holds a Bachelor of Economics in Energy Economics from Beihang University. His work has been

published in journals, including PNAS Nexus, iScience, and Environmental Science & Technology.

Contact

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