# IT sustainability beyond the data center

*Decarbonizing with hybrid cloud*

IBM

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# Key takeaways

*Responsible computing and green IT are essential tools that can help organizations meet their sustainability goals, and hybrid cloud is a critical enabler.*

## Responsible computing and green IT start—but do not end—with physical data centers.

The global power capacity of data centers has grown by 43% in the last 3 years.[1] "Green IT," or environmentally sustainable computing, has become crucial. By engaging in detailed carbon accounting, organizations can better determine how to significantly reduce carbon waste at every layer of the IT operation.

## Sustainable software coding is key.

Software developers can play a pivotal role in promoting responsible computing and green IT. Developers should be encouraged to embrace a sustainable mindset that manifests in the form of green coding and design—using the right language for the right workload to reduce computing power and, therefore, energy usage. Switching from one programming language to another can reduce the energy consumption of an application by up to 50%.[2]

## Hybrid cloud is a green IT catalyst.

Hybrid cloud is a critical enabler of responsible computing and green IT. By facilitating increased visibility, greater integration, and enhanced capabilities across the cloud estate, it can advance organizations further down the net-zero carbon emissions pathway, faster. Running workloads in a container platform instead of in a classically deployed virtual machine (VM) environment can reduce annual infrastructure costs by 75% thanks in part to increased energy efficiency.[3]

# Hybrid cloud can improve performance; responsible computing and green IT can improve the planet.

*Optimization*, *efficiency,* and *transformation* are concepts that business leaders today live by. Not just because they're advantageous to the business, but also because they benefit the environment. In fact, executives increasingly are incorporating sustainability into the core of their business. That much is evident considering that 86% of companies now have a sustainability strategy and sustainability is among the highest priorities in the next 3 years for more than half of organizations.[4]

As organizations create and pursue their sustainability roadmaps, there's a critical lever that can help them achieve better outcomes both for their business and for the environment: digital technologies. And for organizations that pull that lever, green IT is becoming a destination of increasing interest.

Indeed, green IT—the use of environmentally friendly tools and practices by IT operations—is emerging as the new poster child of corporate social responsibility thanks to the convergence of sustainability with digitization.

Case in point: 42% of CIOs say sustainability is an area within their organization where technology will have the biggest impact over the next 3 years.[5]

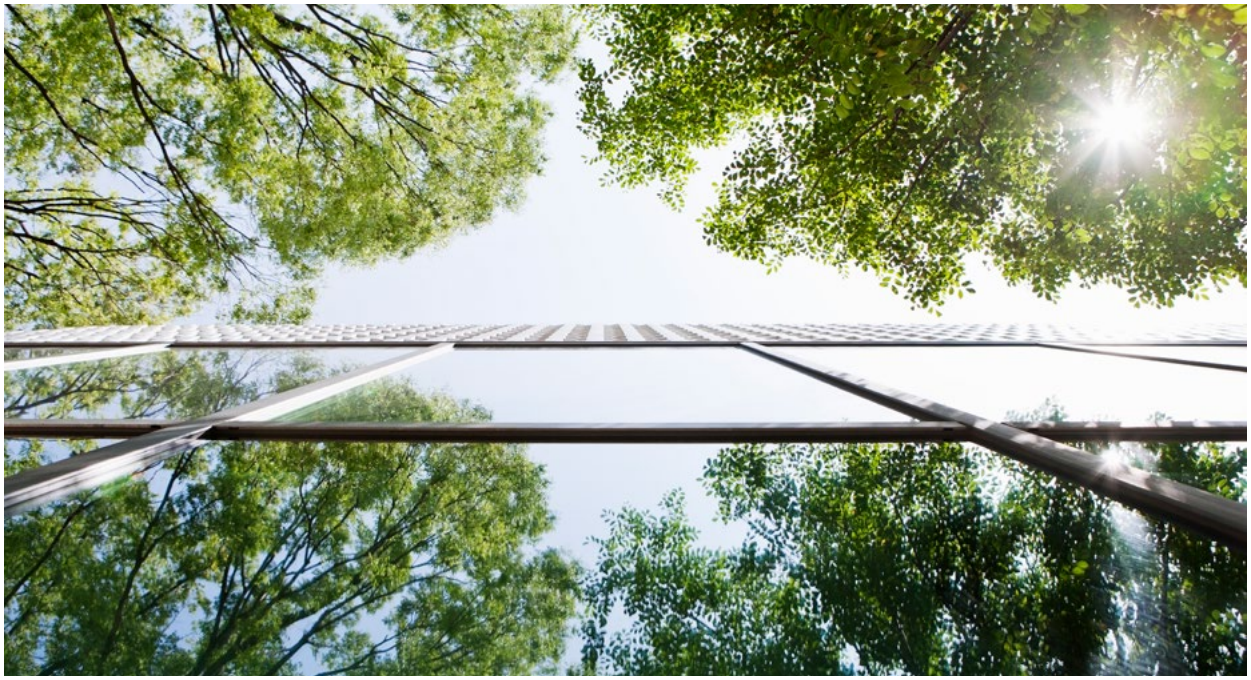
As technology becomes a catalyst for sustainability, CIOs will be pivotal to the success of enterprise sustainability initiatives. "Chief information officers have emerged as key players in their companies' sustainability programs, leading efforts to unload power-hungry computer-processing applications to the cloud and roll out tech aimed at energy optimization and waste reduction," *The Wall Street Journal* reported early this year.[6]

The operative word there might be *cloud*, as 97% of enterprises have either piloted, implemented, or integrated cloud into their operations.[7] More specifically, hybrid cloud now supports the vast majority of sustainability initiatives undertaken by organizations. In fact, 70% of sustainability leaders use hybrid cloud to advance their sustainability objectives.[8]

Clearly, cloud—and hybrid cloud, in particular—is driving transformation and sustainability initiatives for the wider enterprise. And yet, the environmental impact of cloud itself can be significant: cloud-based software runs on computers and mobile devices but actually lives on hardware in remote data centers. Although the software itself does not consume energy, the hardware on which it relies—including processors, memory, storage, and networks—most certainly does.

Hybrid cloud opens up new opportunities for "greening" IT. Instead of a narrow focus on the energy efficiency and emissions of individual servers or data centers, it allows CIOs to focus on improving the sustainability of their entire cloud estate and IT operations. As CIOs expand their focus on reducing the carbon footprint of their organizations, they can leverage hybrid cloud for their data, workloads, and applications, helping reduce the amount of energy consumed across the enterprise.

But deploying hybrid cloud to the shared benefit of Earth and the enterprise is not as easy as flipping a switch. Rather, it requires a keen understanding of IT's environmental impact, the fundamental challenges facing green IT initiatives, and the critical levers that organizations can pull to make their IT more sustainable—not only within carbon-intensive data centers, but across their IT operations.



# Understanding IT carbon footprints

Hybrid cloud opens up new opportunities for "greening" IT.

To make their IT operations green, business leaders must first understand what generates their carbon footprint. There are typically 4 main interrelated sources of carbon emissions: data centers, big data and analytics, security and cryptography, and internet consumption (see Figure 1 on p. 5).

Collectively, data centers around the world consume 200 to 250 terawatt-hours (TWh) of electricity, according to the International Energy Agency (IEA). That's roughly 1% of global electricity demand and approximately 0.3% of all global carbon emissions.[9] Demand for data centers and network services will only continue to grow in the future, consuming even more electricity and producing even more carbon. Some estimates suggest that there has been a 43% absolute increase in the power capacity demand by data center operators between 2018 and 2021, and that the global data center market will grow by more than 30% between 2021 and 2027.[10] Therefore, action to support further efficiency improvements, lower energy consumption, and reduced carbon impact from data centers is critical.

A principal driver of demand for data center capacity—and for electricity with which to power data centers—is the voracious appetite for data-driven analytics to assist in decision-making, coupled with the accessibility of both on-premises and cloud-based computing power. Moreover, as data infuses ever more business processes and decisions, the need for security grows accordingly. Because they require more computation, encryption mechanisms, application security, blockchain, and CPU-intensive algorithms can increase the energy demands of software, which also increases its carbon footprint.

In addition, with people spending more time living and working at home during the COVID-19 pandemic, streaming entertainment, video conferencing, online gaming, and social networking accelerated. As a result, global internet traffic surged by more than 40% in 2020. This growth is on top of the increased demand for digital services before the pandemic: since 2010, the number of internet users worldwide has doubled and global internet traffic has expanded 15-fold.[11] As internet traffic continues to increase—with the expansion of the Internet of Things (IoT), for example—so, too, will IT emissions.

FIGURE 1

**Carbon and computing**

At its best, technology generates information, efficiency, and productivity. Unfortunately, it also generates carbon.

# 4 major sources of emissions

## Data centers

Globally, data centers consume 200 to 250 terawatt-hours of electricity.*

## Big data analytics

Increased demand for data has created increased demand for servers—and, therefore, for electricity.

## Security

Adding security features to software can increase its energy needs.

## Internet usage

Since 2010, the number of internet users worldwide has doubled and global internet traffic has expanded 15-fold.*

**Source: Kamiya, George. "Data Centres and Data Transmission Networks." International Energy Association. November 2021. https://www.iea.org/reports/data-centres-and-data-transmission-networks*

# Green IT challenges

IT organizations must have tools with which to accurately measure their carbon emissions.

To foster growth that's as responsible as it is robust, strong government and industry efforts are needed in the next decade to promote energy efficiency; encourage procurement of renewable energy sources; and stimulate green IT research, design, and development.

But scaling green IT won't be easy. To be ready, IT leaders must begin to address 3 significant challenges:

## 1. Complex carbon accounting

In order to reduce the carbon footprints of data centers, applications, and infrastructure, IT organizations must have tools with which to accurately measure their carbon emissions. Although they may currently have limited availability and capability, such tools are in development and will play an important role in the greening of IT going forward.

Carbon accounting is made more complex by the rise of cloud computing. In some sectors, like banking and finance, most organizations are still running many of their workloads through private data centers due to concerns about information security, customer data confidentiality, and cross-border data-sharing regulations. For these private data centers, carbon accounting is an internal responsibility.

Across many sectors, most organizations have moved at least some of their workloads to public clouds, in which case carbon accounting generally is done externally by hyperscalers. But with the average organization on more than 8 clouds today, and moving to more than 10 by 2023, the majority of organizations will have assets in a combination of on-premises, private data centers, and public clouds.[12]

Organizations will need carbon accounting across the entire estate and will need to devise ways of converging disparate data to create a single operating picture.

## 2. Opaque benchmarks

Even if they have a clear and accurate accounting of their carbon footprint, organizations need context in the form of benchmarks—internal and external key performance indicators (KPIs) that give them a sense of their performance and their progress. This will require clarity on what constitutes appropriate performance metrics and standards for measurement and data gathering.

Because green IT is in its earliest stages, there are few established standards or metrics for effective benchmarking. In the absence of such standards, organizations must determine their own KPIs and ways of measuring performance. To advance on the path to green IT, establishing benchmarks and standards will be a key accelerant.

## 3. Ambiguous analytics

Once organizations can easily, affordably, and accurately measure and benchmark the carbon footprint of their IT estate, they will have a better sense of where they are and where they want to go. To get from point A to point B, however, they still need to turn ambiguous analytics into decisive action. That requires solutions and expertise to help them interpret carbon accounting data and identify what actions to take, in what areas, and during what timeframe. To reduce carbon emissions across their entire stack of solutions, for instance, organizations must be able to choose the right architecture, the right modernization journeys, and the right migration paths.

To advance on the path to green IT, establishing benchmarks and standards will be a key accelerant.

# Moving beyond the data center

Forward-looking IT leaders should look beyond the data center and fix their gaze on ... operations and platforms.

Despite the challenges they face, IT leaders can take concrete steps today to make their organizations more sustainable as they pursue a hybrid cloud future. The foundation for action is a 3-pronged approach to green IT (see Figure 2 on p. 9).

Because the first prong—data centers—is responsible for so much of their IT carbon footprint, many organizations already are engaged in work to make it more sustainable. Whether a data center can be considered green and to what extent depends on a multitude of variables, including power capacity utilization, physical space utilization, innovations in cloud computing deployments, HVAC efficiency, waste heat utilization, renewable energy usage, and even geographic location.

To shrink their carbon footprint, organizations already are completing projects in each of these areas with the goal of making resource-hungry data centers more environmentally friendly. As far back as 2010, for example, IBM built a hot-water-cooled supercomputer for the Swiss Federal Institute of Technology in Zurich, Switzerland; called Aquasar, the supercomputer consisted of special water-cooled servers that consumed 40% less energy than comparable air-cooled machines.[13]

With data center optimization becoming table stakes for sustainable enterprises, forward-looking IT leaders should look beyond the data center and fix their gaze on the remaining prongs of green IT: operations and platforms, which contain underutilized opportunities for organizations to significantly reduce emissions and optimize efficiency.

FIGURE 2

**How to achieve cleaner, greener IT**

Organizations can become more sustainable by pulling levers in 3 major areas of green IT.

| | Area | Potential lever |
|---|---|---|
|  | Data centers | – Optimize performance of the chiller plant and HVAC system<br>– Use building controls to automate resource consumption |
|  | IT operations | – Optimize resource utilization<br>– Schedule IT workloads to exploit periods of high renewable energy in the grid<br>– Use cloud economies of scale to reduce your energy footprint |
|  | IT platforms | – Migrate applications to public cloud<br>– Build applications using sustainable design principles and responsible coding<br>– Embrace mainframe modernization to optimize transaction processing with fewer resources<br>– Leverage a hybrid cloud platform with hyperscaler services to help achieve more efficient measurement and remediation |

## IT operations: unlocking efficiency

In order to be healthy, happy, and productive, human beings have to take care of not only their physical health, but also their mental health. IT organizations are similar. In order to be sustainable, they have to enhance not only their physical facilities, but also the operations that take place within them.

One key opportunity for IT leaders to enable organizational health is to embrace the concept of the software-defined data center.

IT organizations ... have to enhance not only their physical facilities, but also the operations that take place within them.

Software-defined data centers are commodity markets that enable entities like applications, virtual machines (VMs), and containers to self-organize, making placement, sizing, and provisioning decisions that help ensure workloads get the resources they need to perform well. In this model, every entity in the supply chain is a buyer and a seller, and every resource—compute, memory, network—has a price. As resource utilization increases, so does cost.

This market-based approach allows data centers to independently shop their workloads around in an automated fashion in search of the best overall price for the resources they need. In so doing, they can make local resource decisions based on real-time demand across their entire ecosystem.

When making local resource decisions, one of the most favorable choices data centers can make with regard to energy efficiency is to increase server utilization. That's because the average server runs at a mere 12% to 18% of its full capacity while still drawing 30% to 60% of maximum power, the Natural Resources Defense Council (NRDC) reports. Furthermore, idle "zombie" servers continue to run 24/7, consuming energy while providing little to no value.[14]

One reason for low server utilization is performance: data centers historically had to keep server loads low to maintain performance and avoid outages. But increased server utilization no longer has to come at the expense of performance or business continuity. New approaches to data center management—for example, the use of distributed control systems for advanced data center monitoring—permit servers to run at higher rates of efficiency without risking outages or impacting application performance.

Even more compelling than what can be avoided is what can be gained: by implementing just half of technically feasible improvements, including increased server utilization, data centers in the US could reduce their electricity consumption by as much as 40%, NRDC says.[15] Increasing server utilization yields numerous benefits both for the environment and for the enterprise, including reduced energy consumption, a smaller carbon footprint, and lower operating costs.

Another opportunity for green IT operations is the geospatial movement of workloads based on the composition of data centers' grids. A key lever for batch workloads, this requires intelligent controllers that can manage workloads by dispatching them across multiple data centers according to when those data centers are drawing power from renewable sources. Such controllers can recognize when the power grid of a given data center is clean and execute workloads within the data center only at that time.

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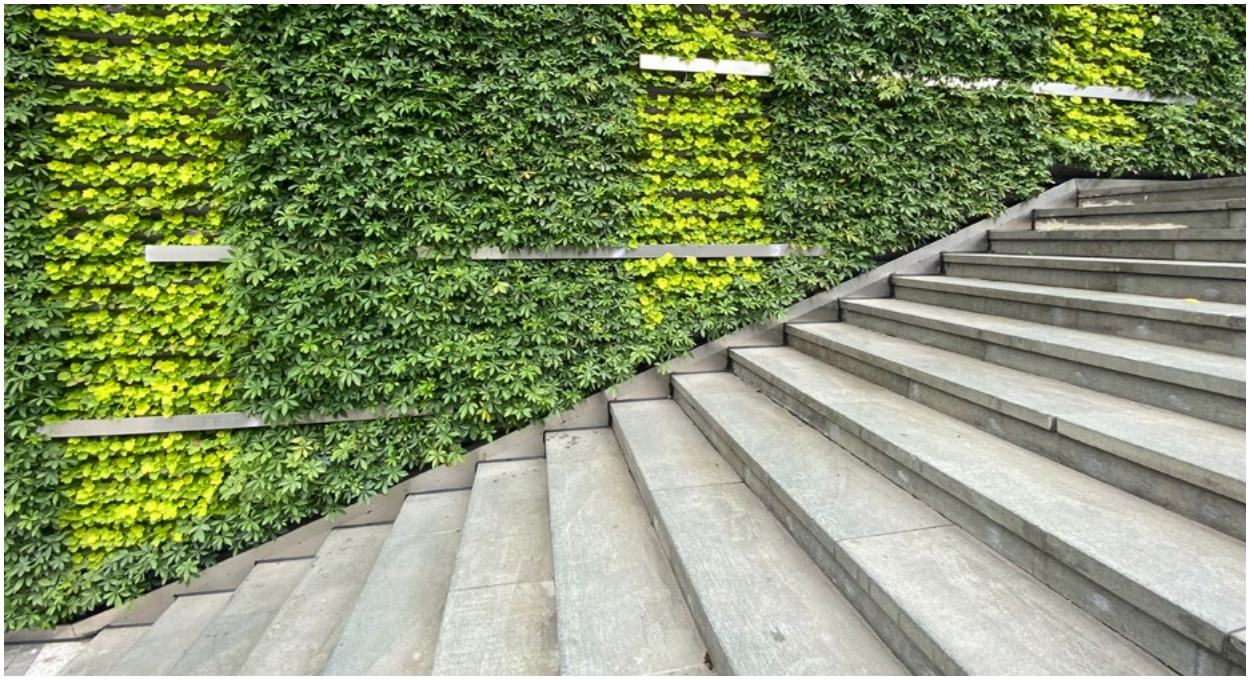

**Perspective**

# European bank: Creating a roadmap to green IT

The CIO of a leading private bank in the UK had long aspired to adopt a "game-changing" technology that would help the organization develop a roadmap toward sustainable and resilient IT. Unfortunately, the bank for many years was unable to calculate the greenhouse gas emissions from its private data center, and therefore could not take appropriate actions to reduce its carbon footprint.

The bank approached the challenge by calculating the carbon footprint of its many private data centers and developing a roadmap for optimizing its IT resource utilization. Meanwhile, it also pursued migration and modernization with the goal of reducing carbon emissions and reducing operational costs.

It began with a small dataset that served as a proof of concept (PoC). The results to date have been very encouraging and have sparked intense architecture discussions in the course of building a solution roadmap. The PoC revealed significant underutilized IT resources and higher core servers, both of which represent massive opportunities for optimization by tactical as well as strategic means. Consequently, the bank now wishes to scale the solution across multiple data centers and its larger IT estate using diversified infrastructure and platforms across multiple business areas. Doing so, it believes, will help it realize much greater benefits around carbon footprint measurement and optimization while reducing its overall operational cost.

One recent project revealed that the idle power of higher core VMs consumed a considerable amount of energy, while very little energy was consumed as dynamic power for providing business functions and related workload. By identifying these hotspots and rightsizing its VMs, the bank was able to create a proof point to reduce carbon emissions across its IT estate, reduce operating costs by using fewer compute resources, and reduce its spending on energy at the data center level.

## Platforms: sustainable from the start

Green IT starts with facilities and continues with operations. But it culminates with platforms.

Indeed, there are many optimization levers for applications and infrastructure at the platform level that can reduce consumption of compute, storage, and network resources. Among them are application migration and modernization, z/OS modernization, data modernization, server consolidation, and cloud-native builds.

Pulling these levers in ways that facilitate sustainability requires both tactical and transformational approaches.

An effective tactical move is reducing idle cloud resources, which create both economic and environmental waste in the form of unnecessary costs and carbon emissions. Common types of unused resources include:

- Unused active cloud resources—for example, keeping VM sessions open when a workload has completed, instead of terminating them;
- Over-provisioned resources—for example, using more or larger VMs than necessary for a given workload; and
- Non-optimal architectures or workflows—for example, using lift-and-shift applications that were migrated to the cloud but not optimized for it or using storage and compute infrastructure that should be separated for data processing and analytics workloads but isn't.

Addressing unused and over-provisioned VM resources can have a significant impact for organizations that want to reduce both their costs and their carbon footprint.

Transformational strategies can complement tactical initiatives. Especially fruitful, for example, can be the application of "green thinking" to IT architecture and design. Specifically, green thinking encourages IT architects to build solutions that have sustainability baked into them from the start. Non-optimal architecture leads to inefficient use of cloud resources. Of course, architectural issues can still occur with applications that are custom-built for the cloud, but such issues are most common with applications that aren't—for example, monolithic "lift-and-shift" applications that were migrated to public cloud with no or very little optimization.

When architecture progresses to coding, another opportunity emerges: green coding, or responsible coding, which helps applications run more efficiently by building them with coding practices that optimize speed and stability. At the heart of green coding is code efficiency—writing algorithms and software that take the path of least of resistance. With efficient algorithms and fast runtime execution, software can deliver more benefits with less risk, while also consuming fewer resources.

Moreover, using the Rust programming language could reduce an application's energy consumption by up to 50%.[16] Similarly, functions written in C are 75 times more energy-efficient than functions written in Python.[17] And preferencing string literal initialization could reduce energy consumption by nearly 92%.[18]

# Fulfilling the promise of green IT with hybrid cloud

With hybrid cloud, organizations can create the visibility, integration, and capabilities they need to drive sustainable outcomes.

A decade ago, sustainability was largely peripheral to the core business—something leaders might have embraced if it were easy, convenient, or complementary to their brand. Today, sustainability is a business imperative—something executives in businesses of all sizes and types must embrace to satisfy boards, investors, employees, consumers, and governments.

Forward-thinking IT executives are taking note and pursuing sustainability in earnest. In many cases, however, something is conspicuously absent from their efforts: digital technology. Enterprises that want to reduce their carbon footprint—and eventually become carbon-neutral—can no longer afford to confine their sustainability strategies to facilities, administration, and operations. In lockstep with their digital transformations, they must expand the scope of their sustainability goals to include IT.[19]

Indeed, the next step for leaders that have already cultivated energy-efficient offices, carbon-neutral vehicle fleets, paperless meetings, and sustainable supply chains is to foster green IT, hallmarks of which include resource-conscious data centers, environmentally friendly IT infrastructure, and efficient software code.

If green IT is the destination, then hybrid cloud is the mode of transport. With hybrid cloud, organizations can create the visibility, integration, and capabilities they need to drive sustainable outcomes. Not only within a single cloud or a single data center, but across the cloud estate—and therefore, across the entire enterprise (see Figure 3 on p. 15).

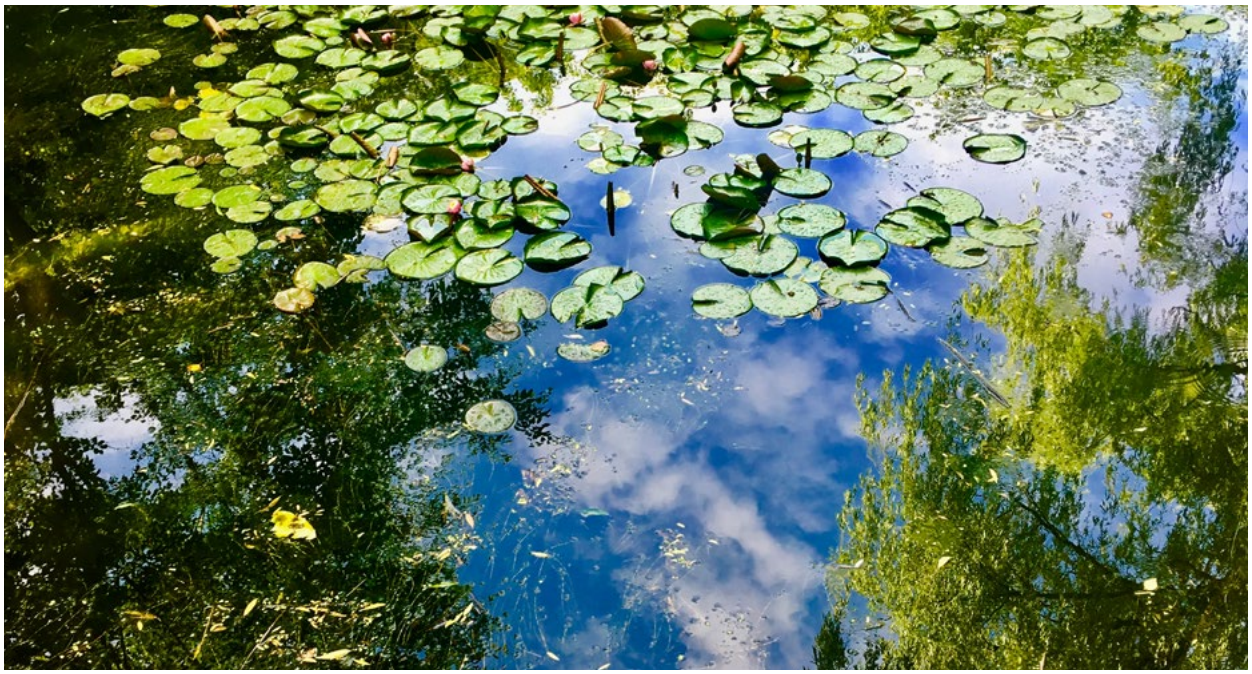

FIGURE 3

**Hybrid cloud is a better choice for green IT**

Hybrid cloud can be more sustainable than both on-premises and cloud.

## On-premises

An on-premises approach can create the following sustainability opportunities:

- Data center design and efficiency
- Renewable energy and energy management
- Optimized application development and deployment

## Cloud

A cloud approach can create all the sustainability opportunities of an on-premises approach, plus:

- Dynamic provisioning
- Improved server utilization
- Multi-tenancy

## Hybrid cloud

A hybrid cloud approach can create all the sustainability opportunities of both on-premises and cloud approaches, plus:

- Optimized workload allocation across cloud estate
- Minimized idle capacity and unused cloud resources
- Containerized workloads

With efficient algorithms and fast runtime execution, software can deliver more benefits with less risk, while also consuming fewer resources.

# Action guide

*For organizations that value sustainability, responsible computing and green IT are not only extremely vital, but also extremely viable. IT leaders can achieve them by pursuing environmentally friendly activities that span IT strategy, operations, and platforms.*

## 01

### Greening your IT strategy

**Embed sustainability objectives within your IT strategy and operations.**

Sustainability should not be its own functional silo. Instead, integrate sustainability into daily operations across your IT ecosystem, encompassing your approach to technology, the way you design your processes, and how you enable your people.

**Create visibility into your IT environmental impact.**

Create or hire carbon accounting capabilities; knowing the size of your carbon footprint will help you take a holistic approach to reducing it.

**Leverage hybrid cloud for sustainability.**

Tap hybrid cloud platform capabilities to allow you to integrate, manage, and optimize for sustainability across your cloud estate. Use hybrid cloud to create fewer carbon emissions without impacting business continuity and application performance.

## 02

### Greening your IT operations

**Optimize utilization and consolidate capacity of existing resources.**

Nearly half of the global IT workload (44%) is non-production workload, which collectively costs organizations $14.5 billion per year.[20] Optimizing non-production workloads can lower operating costs and reduce global carbon emissions from data centers.

**Refresh your hardware.**

Continuously refreshing hardware with the newest chips and the latest technology will allow you to run more workloads using similar compute resources, thereby reducing your energy consumption overall.

**Dynamically control the state of servers.**

Use financial operations (FinOps) tools or AI-enabled agents to identify extraneous VMs and idle "zombie" servers. Deploy a host-utilization-aware (HUA) algorithm for underloaded host detection and place its VMs on other hosts in a dynamic cloud environment. Further reduce energy consumption by dynamically scaling VMs or services based on network traffic.

**Optimize workload schedules for sustainability**

Determine where your data centers are connected to grids that utilize renewable energy sources and at what times those grids draw power from those energy sources. Use an AI-enabled rule-based system for scheduling workloads to run at the appropriate data centers and at the appropriate times to reduce carbon emissions.

# Action guide

## 03

### Greening your IT platforms

**Use refactoring to migrate applications to public cloud.**

Migrating workloads to public cloud without first making them cloud-optimized can not only increase operating costs, but can also have an adverse impact on sustainability. Instead, make workloads more cloud-native by refactoring applications based on their lifecycle, the frequency with which they're updated, and their business criticality.

**Optimize idle VM capacity and other unused cloud resources.**

Enable observability at the infrastructure level to identify idle VMs across your IT estate, then implement rules-based automation to take corrective actions—including deleting idle VMs and associated resources that are no longer fulfilling business functions. Likewise, optimize the size of VMs by regularly checking for rightsizing recommendations to reduce wastage from overprovisioning. Finally, consider scheduling VM instances to automatically start and stop if VMs are needed only at certain times.

**Create resources when they're needed.**

Although cloud resources are elastic, you gain limited efficiency benefits if you deploy workloads to fixed resources that run continuously, regardless of actual usage. Identify opportunities to provision and delete resources as they're needed, such as using VM scheduling or elastic features within cloud services.

**Containerize workloads.**

Running workloads in a container platform instead of in a classically deployed VM environment can reduce annual infrastructure costs by 75% thanks in part to increased energy efficiency.[21] When using a container platform, you can efficiently schedule containers across a cluster of VMs based on their resourcing requirements. If resourcing requirements allow, multiple containers can also share the resources of a single VM.

**Modernize your monolithic applications to microservices-based architecture.**

Select reactive microservices for event- and action-based invocation that will optimize resource utilization, event-driven microservices for asynchronous invocation, or serverless microservices when there is a need-based execution of a single function that can be implemented as microservices.

# Action guide

**Locate compute resources close to the customer to achieve lower network latencies and faster response times.**

Use a content delivery network to help ensure low latency across the globe and caching to help ensure visitors don't have to fetch fresh content from halfway around the world every time they visit your website. Introduce edge computing to efficiently utilize resources on public cloud without moving data, and leverage function-as-a-service (FaaS)—or event-driven managed services provided by different hyperscalers—to help reduce energy consumption and operating costs.

**Adopt responsible coding methodologies.**

Embrace "code efficiency" to improve the reliability, speed, and performance of your applications. For example, remove unnecessary code or code that goes to redundant processing, and use reusable components wherever possible. In addition, use optimal memory and nonvolatile storage, and try to ensure the best speed or run time for completing algorithms.

**Optimize transaction processing with fewer resources.**

To achieve faster data processing, it's common to expand central processing units (CPUs) or optimize system global area (SGA) size. However, that can sometimes have an adverse effect by increasing CPU cycle time. Instead, make it a best practice to try the path of fewest resources first and to increase resources only when needed.

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