



Datacenter Sustainability



Microsoft is committed to software and technology innovations that help people and organizations around the world improve the environment.

In this strategy brief, learn about Microsoft's environmental sustainability imperative and how advanced technologies, smart business practices, and strategic partnerships are helping to reduce our impact on the environment. In addition, learn how our investments in an efficient, sustainable, cloud infrastructure can help organizations around the world reduce their own impact.

Microsoft's sustainability strategy

Three themes define Microsoft's environmental sustainability strategy: reducing the impact of our operations, enabling resource efficiency with and through IT, and accelerating research breakthroughs that benefit society at large.

Reducing the impact

Our overriding goal is to minimize our impact on the environment by becoming carbon neutral in our own operations, utilizing an internal carbon fee that charges internal groups for each metric ton of carbon emissions associated with the operation of our datacenters, software development labs, office buildings, and employee travel.

Enable resource efficiency

We continue to significantly invest in developing software and tools to help reduce energy consumption for the software and devices we support, but go further in applying new research to drive more efficiency in buildings, transportation, and supply chains, while also applying more effective monitoring and management of the energy we use. We also work with industry partners like Johnson Controls and Alstom, who are also delivering solutions that allow customers and consumers around the world to realize even greater levels of efficiency.

Accelerating research breakthroughs

Scientific research into the impact that humankind has on complex environmental and biological systems will continue to help provide the insights needed for effective policy change in government and increased environmental awareness among the population. It will also provide the foundation for technological advancements in energy usage, resource management, and environmental planning.

Microsoft Research is working with leading scientists worldwide to expand the boundaries of our knowledge of the planet. We're also working to create the tools, technologies, and models to help expand and accelerate scientific understanding on a global scale.

A commitment to sustainable practices in our own operations is only one part of the impact we can make. A greater contribution is through sharing our learnings and best practices across the industry.

At Microsoft, we believe there are three tenants to responsible environmental leadership: Be Lean, Be Green, and Be Accountable.

Be Lean – Reduce energy use and air travel through technology-driven efficiency. Microsoft has continued to reduce energy consumption in our datacenters, development labs, and offices. In our latest datacenter designs, the Power Usage Effectiveness (PUE)—a measure of overall building load divided by IT load—average 1.12-1.2 depending on physical location, representing a substantial energy reduction versus the industry average of 1.8.

Be Green – Increase our purchase of renewable energy and reduce waste and water use. We are working through a portfolio of approaches, including purchasing renewable energy, searching for innovative new technology that enables low carbon energy to power our sites, and powering our datacenters directly from on-site renewable energy sources. Later in this brief, we will discuss our recent pilots using biogas to power a Dataplant and using rack-mounted fuel cells to directly power server infrastructure.

Be Accountable – Measure the impact of our operations and incentive reductions in emissions. Microsoft has committed to Carbon Neutrality for all internal operations across the more than 100 countries, our 100-plus datacenter locations, software development labs, offices, and air travel.

Microsoft's carbon fee

By assessing an internal carbon fee for all business groups based on current market pricing for renewable energy and carbon offsets, we are driving company-wide consciousness and incentivizing behaviors that reduce our overall environmental impact.

Our carbon fee requires that all business groups and corporate subsidiaries build the price of carbon into their budgets. These groups are able to limit their "carbon liability" by using less energy—either through efficiency or conservation—or by directly sourcing renewable energy. The groups pay a carbon fee into a central fund at Microsoft for each metric ton of carbon emissions associated with their operations and the carbon price is based on the cost to purchase renewable energy and carbon offsets to reduce our emissions.

Over time our carbon price will evolve to reflect the regional purchase price for the renewable energy and carbon offset projects specifically purchased in areas of our operations where possible.

Microsoft has initiated a number of programs to measure and reduce the impact our employees have on the environment:

- With a flex-work policy plus our unified communications and online collaboration tools, our employees can work from home effectively, helping cut back on daily commuting travel – saving over \$90 million per year in travel costs and 17,000 metric tons CO₂.
- In Puget Sound, WA, employees can take the Connector bus to and from work—this service has helped eliminate 46.3 million miles of travel and reduced carbon emissions by 19,936 metric tons since its debut five years ago.
- We have reduced, reused, or recycled 99 percent of the waste from our Redmond dining facilities by switching to compostable tableware, administering aggressive recycling programs, and adapting our menu to get the most from each item of food served.
- Each month we recycle an average of 475 metric tons of material at our Puget Sound campus, including glass, plastic, aluminum, electronics, cardboard, paper, organic waste, wood pallets, and copper wire.

Leveraging technology to reduce global impact

The IT industry is reportedly responsible for two percent of all worldwide emissions, about the same as the airline industry. However, IT can have a significant impact on the other 98 percent by enabling more sustainable business practices, creating greater efficiencies, and inserting smarter controls into everyday operations.

We're leveraging software to create more efficient buildings and cities. Through Microsoft's CityNext program, Microsoft and its worldwide partners seek to provide municipalities with the services and devices to be more sustainable and economically competitive. Cities that take advantage of Microsoft technologies and partner solutions are improving operations and reducing consumption, by using software to collect and analyze both real-time and historical data from a wide range of sources, including renewable energy systems. The information can be used to cut power costs, improve forecasting, and detect impending equipment failures.

Microsoft can help organizations achieve greater sustainability, while reducing their cost of operations. From the desktop to the datacenter and beyond, the latest generation of technologies and productivity tools enable a level of efficiency that was not possible just a few years ago.

Reducing energy demands – on the desktop, the advanced power management capabilities in Windows allows IT to manage power settings centrally through group policy, ensuring monitors power down overnight and PCs go to sleep when idle. In the datacenter, Hyper-V

enables server consolidation through virtualization, requiring less hardware and supporting infrastructure, while maintaining workload security isolation and continuity. These technologies result in measurable reductions in energy consumption and carbon emissions.

Managing environmental footprint

– the foundation of environmental management is measurement and using the information to understand precisely where energy is being used and potentially wasted. Centralized control is a necessary component to allow IT to identify problems and curb excessive use. The metering and reporting on energy usage and carbon output available in Microsoft System Center 2012 R2 allows better-informed control over both. Small and medium-sized businesses can measure and manage their carbon footprint from greenhouse gas emissions using Microsoft Dynamics AX and its integrated Environmental Sustainability Dashboard.

Rethinking business practices – often the greatest strides involve not just reducing the impact of current practices, but changing the way people behave and work by replacing physical processes with digital processes, and using communication and collaboration tools, such as Microsoft Office 365, that improve employee productivity while reducing the need to travel. In IT, it can mean moving workloads from on-premise resources to cloud-based services that take advantage of greater scale and efficiency. And across all operations, it means aligning incentives to drive responsible behavior.



Which is more sustainable: Cloud vs. On-premise IT?

Businesses and thought leaders around the world are asking, “Is the cloud more efficient and sustainable than on-premise IT operations?”

To find out, we engaged our partners Accenture and WSP to conduct a study assessing the impact of moving Microsoft Exchange, SharePoint and our Dynamics CRM workloads from on-premise to a hosted cloud. They found that when organizations move these services to a Microsoft hosted cloud, they are able to reduce their per-user carbon footprint by at least 30 percent, and in the case of small businesses, this result was even more dramatic—a potential savings of up to 90 percent.

What is behind these efficiencies? Microsoft employs a number of technologies and practices in our datacenters that improve overall efficiency, many that are only available at large scale:

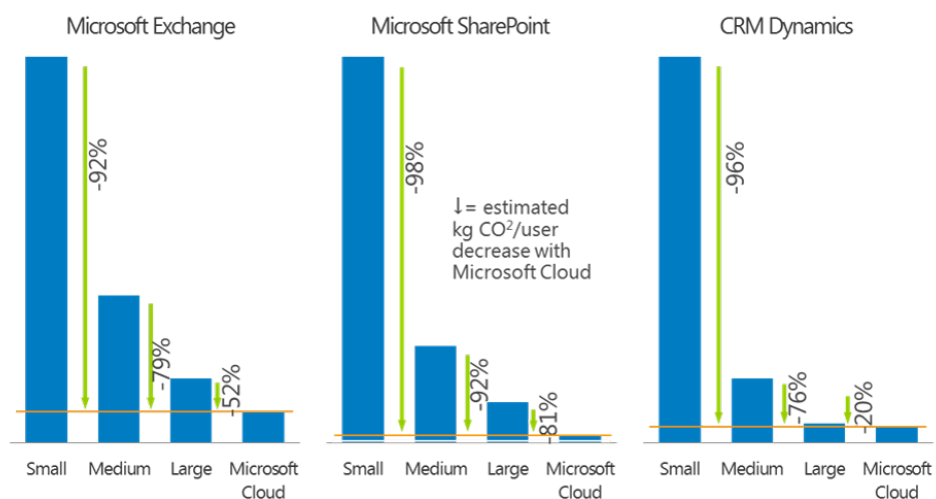
Dynamic provisioning – when an organization plans its physical IT infrastructure, it generally must anticipate demand for several years out. Given the nature of large capital investments, it is common to over-provision capacity to ensure a comfortable margin for unexpected growth. Scaling back capacity when the expected demand fails to materialize is generally not an option. With a cloud computing model, adding capacity does not require additional capital outlays and equally important, scaling back capacity in response to reduced demand is quite practical. Quickly matching server capacity to variable demand reduces waste.

Multi-tenancy – just as multiple tenants in an apartment building use less power overall than the same number of people living in individual homes, the multiple tenants of a cloud-provided infrastructure reduce their overall energy usage and carbon emissions. Cloud providers at our hyper-scale also have the ability to balance capacity among tenants with offsetting demands – such as differing time zones or seasonal business spikes—allowing optimal resource usage.

Server utilization – using virtualization technologies allows a datacenter operator to consolidate multiple workloads per server, while maintaining isolation of each workload. This drives up utilization from a typical 11-15 percent to 50 percent or higher, resulting in significant energy savings and reduced carbon output.

Datacenter design – each generation of our datacenter design is yielding major gains in efficiency and sustainability. Microsoft has pioneered the use of free-air cooling and ultra-efficient water utilization in the latest modular designs, and uses recyclable materials for construction. Our modular datacenters use about 50 percent less energy than those from just three years ago, and we continue to evolve our innovative designs and operating practices to reduce energy use even further. In addition, renewable energy sources factor heavily in site selection. Microsoft’s datacenters are among the most monitored and metered in the world, informing operations that are more efficient and identifying areas for future research.

Current On-Premise vs. Cloud: kg of CO₂/User Comparison



Reducing the impact of our cloud infrastructure

Reducing the impact of our cloud infrastructure comes down to three core concepts:

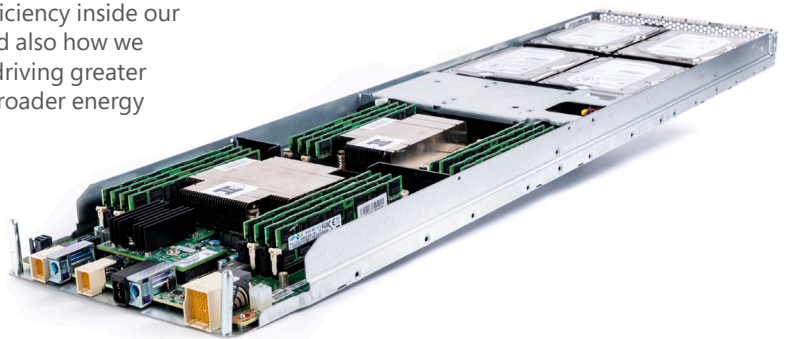
- Building from the ground up with sustainability in mind, such as choosing sustainable materials, and finding locations where renewable energy is available and accessible.
- Operating our datacenters to optimize for efficiency, to increase utilization, and to better monitor and manage power consumption. Data and analytics are playing a critical role in allowing us to tune for efficiency in our datacenters.
- A commitment to utilizing 100% Renewable Energy.

At Microsoft, we look at data as just a refined form of energy. As a result, our path for delivering power to supply Microsoft's cloud infrastructure is focused both on how we optimize for efficiency inside our datacenter footprint and also how we integrate and invest in driving greater efficiencies across the broader energy supply chain.

We have three overarching goals that drive us in this effort:

1. We distribute hyper-efficient power generation to the datacenter that radically reduces the amount of energy required to deliver cloud services
2. We deliver to the grid low-cost and efficient energy through participation in utility-scale generation projects.
3. We foster the development of the next generation of energy technologies that will make future distributed and grid-connected projects radically more efficient.

We are not just concerned about efficiency inside the datacenter, but rather we are focused on how to create systems, from the power plant to chip, that are dramatically more efficient than anything that's been done before.



Microsoft's Open CloudServer

A major initiative in Microsoft's datacenters involves designing our own server specifications that are optimized for a massive, hyper-scale cloud infrastructure environment. These specifications evolved into a [new server design](#) that significantly reduces power consumption and improves operations efficiency. We also shared this design with the industry through our contributions to the [Open Compute Project](#) Foundation in 2014.

Microsoft's Open CloudServer was built around a number of key principles including:

- Simplicity of design
- Efficiency across cost, power, and performance vectors
- Modularity to accommodate evolving workload requirements
- Environmental sustainability that involves minimizing material use and ensuring re-use of components wherever possible

When operating a \$15 billion-plus cloud infrastructure of more than 1 million servers and 100 datacenters globally, we are faced with unprecedented challenges associated with how to design, build, and operate a massive cloud infrastructure, and we must also consider how to decommission and refresh hundreds of thousands of components every year.

This involves having a structured rotation plan that allows for efficient server refreshes. This also entails recovering, reusing, and recycling server components, as well as electrical and mechanical rack infrastructure, which in addition to reducing costs and waste, can also accelerate the rate of deployments.

Finally, it is critical that any decommissioning plan evolve active wiping and destruction of hard drives to ensure the protection of customer data.

Advancing datacenter sustainability

Waste-to-energy One example of our continuing research into more efficient energy production for datacenter infrastructure is our DataPlant research project underway in Cheyenne, Wyoming that is powered by a wastewater treatment plant. This project has many significant benefits for the industry and us, both today and as we look out into the future.

The first advantage of this approach is that it is scalable and will be cost efficient. The second advantage is that this facility is relying 100 percent on renewable energy. Plus, it is extending knowledge on fuel cells, both how they can operate inside a biogas environment, and in conjunction with the datacenter. It is also aiding the host wastewater treatment plant to improve efficiencies in its own operations by reusing the waste heat typically lost in the power generating process. Ultimately, we are trying to achieve best practices for how to use renewable energy to power a datacenter.



Renewable power projects In addition to innovations in on-site generation, we are also focused on bringing new renewable energy to the grid through the development of large-scale power generation projects. Over the last several years, we have signed purchase power agreements for new renewable power generation like in Texas (Keechi), reducing the overall amount of emissions associated with operating our facilities sitting on the same electrical grid. These new sources of renewable power will replace the traditional sources such as coal or natural gas, offsetting millions of tons of carbon dioxide over their useful lives.

These projects help us achieve several important goals simultaneously:

- Purchasing renewable energy is consistent with our commitment to carbon neutrality. We are continually searching for ways to integrate more renewable power into our portfolio to lower our carbon footprint.
- We are also motivated to reduce our long-term cost of power. The economics of wind energy have been improving over the last several years with higher turbine efficiency and lower development costs, such that many wind projects are delivering power to the grid at parity with fossil fuel technologies.
- Finally, grid-connected projects, like this one, align with our datacenter scale and density. To achieve our corporate carbon neutrality objective, we are focused on finding projects that can efficiently scale to match the size of our operations. Projects like Keechi are ideal because they can be sited in locations that are most efficient in terms of wind production and grid integration.

In-rack fuel cell Another research project we have undertaken, is our in-rack fuel cell pilot. As we looked to push the data plant concept to its logical end, we recognized that the ideal approach would be to integrate power generation in the rack itself, essentially collapsing the entire electricity supply chain without sacrificing reliability.

This concept eliminates nearly all of the traditional electrical infrastructure losses in standard datacenter designs, which can represent 1/3 - 1/2 of total datacenter cost, in addition to eliminating all of the electrical losses from transmission and conversion that occur before reaching the datacenter itself.

Ultimately, these programs result in decreased reliance on traditional infrastructure, lower emissions, reduced losses on the electric grid, a more efficient system, and improved application reliability for delivering computational power to our online services customers.

We are gaining tremendous insight from these programs underway and we look forward to sharing additional insights with the industry as our research progresses.

How to get started

How does an organization get started? Make environmental sustainability a priority – understand your energy bills and think holistically about your IT energy consumption, replace older hardware with EPEAT Gold or Energy Star PCs, and empower your employees to continually challenge the use of resources and think about more efficient business practices:

Leverage technology – consider adopting the latest software technologies that allow your organization to better manage PC power consumption and optimize server utilization in the datacenter. Plan, analyze, and monitor your energy use with business intelligence software. In addition, encourage your employees to utilize communication and collaboration tools to reduce their travel.

Adopt proven best practices – provide incentives that support efficiency and sustainability in operations. Invest in understanding application and workload behavior, and right-size your server platforms to meet these workload requirements with minimal waste.

Be proactive and involved – use recycled resources wherever practical and renewable resources wherever available. Take part in industry environmental groups to continue to learn the best practices of others and to share the best practices you discover.

Microsoft has demonstrated a long-standing commitment to sustainability, and are continuously innovating and evolving to drive greater efficiency, reliability, performance, and security across our cloud infrastructure – and actively share our learnings with the industry at large.



Microsoft has extensive experience operating a cloud services infrastructure since 1995. As Microsoft's cloud services portfolio and infrastructure continues to grow we are making thoughtful investments to answer customer needs for greater availability, improved performance, increased security, and lower costs.

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