VMware Helps Create Tomorrow's Sustainable Communications Networks

Telcos Do More with Less and Chart a Course Toward a Zero-Carbon Future

vmware®

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Overview

Sustainability has become a major focus of organizations in every industry, and telecommunications is no exception. Indeed, among environmental researchers, governments, and regulators, Information and Communications Technology (ICT) has emerged as one of the most critical areas to target. ICT already accounts for up to 10% of the world's energy usage,[1] and with connectivity expanding and digital devices proliferating, that share is growing quickly. In response, ICT leaders across the industry have committed to achieving zero-carbon, or at least carbon neutrality, as a core part of their corporate strategy.

VMware is taking a lead role in developing new ICT sustainability innovations, both internally and through projects with our partners around the globe. We're implementing new strategies to help Communication Service Providers (CSPs) and their customers reduce greenhouse emissions, improve energy efficiency, shift to renewables, and break down institutional barriers to more sustainable operations. This paper provides an overview of VMware's efforts in this space.

Meeting the Zero-Carbon ICT Challenge

ICT in general, and telecom networks specifically, play a major role in global greenhouse gas emissions. As businesses and consumers grow more reliant on connected computing, we've seen an explosion of digital devices, communications networks, and data centers worldwide. Data centers in particular burn through enormous amounts of electricity—collectively generating as much CO_2 as the airline industry, according to one 2018 study.[2] And the Global system for Mobile Communication Association (GSMA) estimates that energy consumption now constitutes as much as 40% of overall Operating Expenses (OpEx) involved in running a network.[3]

This problem is only growing, with some studies projecting that ICT will account for as much as 20% of global emissions by 2030.[4] One key driver for this spike: 5G. GSMA estimates that the potential 1,000x increase in data traffic that 5G will unleash, along with the new infrastructure CSPs will need to support it, could double or even triple the industry's overall energy consumption.iii 451 Research projects that as CSPs deploy more network equipment, and more parts of 5G infrastructure runs as software applications in distributed data centers, 5G will increase total network energy consumption by up to 170% by 2026, with the largest increases in macro-node and network data centers.[5]

These trends present significant challenges for CSPs and the broader ICT industry, but also enormous opportunity to make a difference. After all, if ICT plays such an outsized role in global emissions, then even small changes could add up to massive progress towards a zero-carbon future. One study from the Global e-Sustainability Initiative (GeSI) suggests that, if we can work smarter and manage workloads more effectively, the ICT industry can enable a 20% reduction in global greenhouse emissions by 2030. GeSI also estimates that the emissions avoided by more efficient ICT solutions could add up to nearly 10x more than the emissions generated implementing them.[6]

VMware: Advancing Greener ICT Operations

As a longtime partner to CSPs, enterprises, and cloud providers alike, VMware is in an excellent position to help the ICT industry advance towards a zero-carbon future. Improving environmental sustainability has long been a core pillar of VMware's mission, and we've played a major role in reducing greenhouse emissions—both internally and for our customers.

An early pioneer and global leader in virtualization, VMware built its success on helping customers grow their business while using less ICT hardware—inherently reducing energy

ABOUT THIS WHITE PAPER

VMware is a certified carbon-neutral company, powered 100% by renewable energy. And we've set an ambitious agenda to advance sustainability, including radically decarbonizing our supply chain, improving the carbon efficiency of workloads, and fueling the transition to zero-carbon clouds.

VMware is working with our partners and customers to advance sustainability in telecommunications networks across four key pillars of a zero-carbon strategy:

- Improving Energy and Resource Efficiency
- Using Renewable Energy Sources
- Reducing Greenhouse Gas Emissions
- Overcoming Institutional Barriers

This white paper details how VMware is helping the information technology and communications industry advance toward a greener, more sustainable future.

consumption and waste. Over the years, VMware solutions have empowered our customers **to avoid 1.2 billion megatons of CO_2 emissions**. VMware is a **certified carbon-neutral company, powered 100% by renewable energy**. And we've set an *ambitious agenda* to advance sustainability, including radically decarbonizing our supply chain, improving the carbon efficiency of workloads, and fueling the transition to zero-carbon clouds.

Today, we're working with our telecom partners and customers to advance sustainability in the areas of CSP networks where we can make the biggest difference: Radio Access Network (RAN), core, and cloud. For example, as part of the Telecom Infra Project (TIP), we're working with the *Open RAN MoU Group* to help *improve energy efficiency* in Open RAN environments. This work includes expanding choice in power-efficient hardware, developing tools to track hardware and software energy consumption, and developing new Open RAN intelligence, orchestration, and automation features to improve energy efficiency. We're also working closely with the *Next G Alliance*, where we play a lead role in the *Green G Working Group*, helping to keep sustainability front and center as we move toward 6G and beyond.

Recently, VMware researchers authored a *paper* for the *HotCarbon Workshop on Sustainable Computer System Design and Implementation*, laying out untapped opportunities for green computing. VMware is now working on a wide range of projects, internally and with industry groups and customers, across the four key pillars of a zero-carbon ICT strategy identified in that effort:

- Improving Energy and Resource Efficiency
- Using Renewable Energy Sources
- Reducing Greenhouse Gas Emissions
- Overcoming Institutional Barriers

The following sections take a closer look at the work we're doing in these areas to help the ICT industry advance towards a greener, more sustainable future.

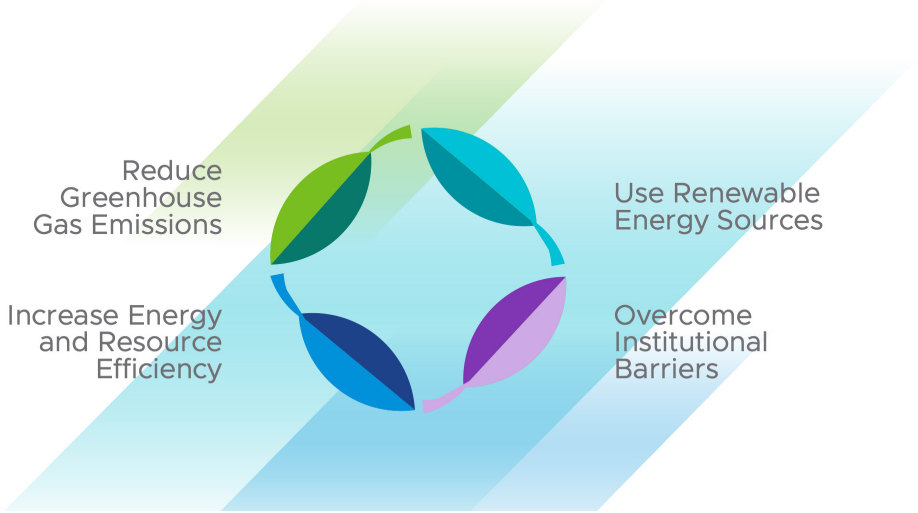


Figure 1: Four key pillars of a zero-carbon ICT strategy.

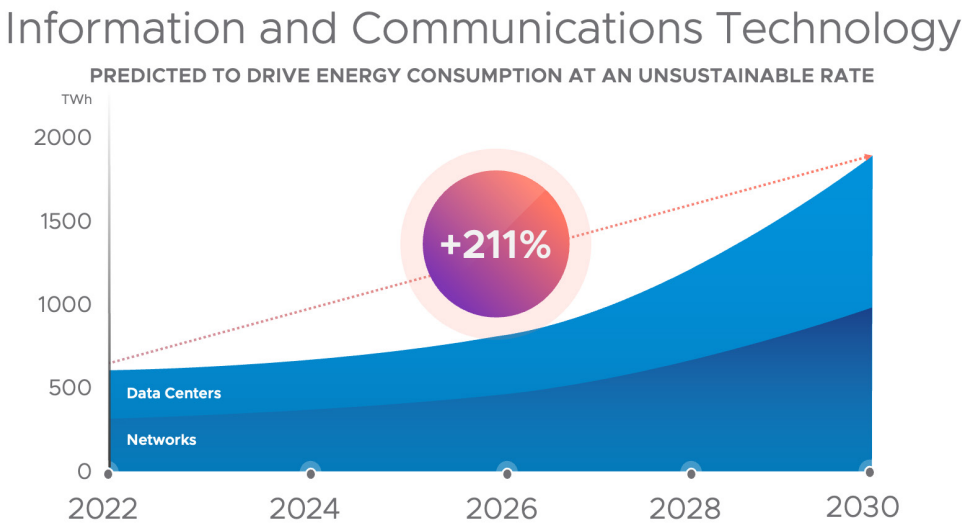


Figure 2: Graph Source: Fierce Wireless Article Carrying 5G energy efficiency momentum into 6G: https://www.akcp.com/blog/data-centers-energy-use-rises-whats-next-for-efficiency

Improving Energy and Resource Efficiency

The majority of the ICT sector's carbon footprint relates to energy consumption—and despite continuing innovation, overall energy requirements continue to grow. Some forecasts suggest that, by 2030, the world's wired and wireless networks will make up more than one fifth (20.9%) of global electricity demand.[7] Naturally then, the most important steps CSPs can take to advance zero-carbon initiatives involve reducing energy consumption and decarbonizing their energy supply.

For telcos, the biggest energy challenge is Radio Access Networks and data centers. According to the NextG Alliance, the RAN accounts for more than half of all energy consumption in the network.[8] Other estimates suggest that, in 2017, RAN base stations alone accounted for about 57% of total power usage in cellular networks.[9] Given this high power consumption, CSPs could make a sizeable dent in their overall energy consumption by using smart power innovations to ensure that base stations consume power only when handling data and signaling. VMware is developing exactly these types of smart energy solutions to improve power efficiency and reduce carbon emissions in CSP networks and data centers.

Improving Data Center Power Efficiency with Virtualization

As noted, virtualization offers a highly effective strategy to reduce data center hardware and networking equipment, improve resource efficiency, and reduce waste. Pioneered by VMware in 1998, virtualization has helped to keep the world's data center energy consumption flat over the past decade—despite a more than 12x increase in Internet traffic and 8x increase in workloads.[10]

In addition to reducing resource requirements by requiring less hardware (see figure 3), virtualization also saves power by optimizing lifecycle management of compute resources. With the ability to manage virtualized resources with a hypervisor, CSPs can:

- Power down data center resources when they're not in use
- Consolidate workloads on fewer resources as they age
- Ensure that workloads with lower requirements are directed to older servers, while more demanding workloads are handled by newer resources

VMWARE RIC AT A GLANCE

VMware RIC™ is a multi-RAN, multi-cloud platform that simplifies the operations of the underlying RAN infrastructure through programmability and intelligence. The platform can host both near-real-time applications (xApps) and non-real-time applications (rApps). These apps introduce new use cases — automation, optimization, service customization, and energy savings — that spark innovation in telco networks.

KEY BENEFITS

- Multi-vendor interoperability establishes a vendor- and technology-agnostic platform for RAN vendors.
- RAN programmability fosters flexibility and agility to dynamically support new applications and services.
- Network-wide observability and automated optimization from AI/ML algorithms improve efficiency.
- Applications from an ecosystem of partners optimize the RAN, improve spectrum utilization, and reduce energy consumption.

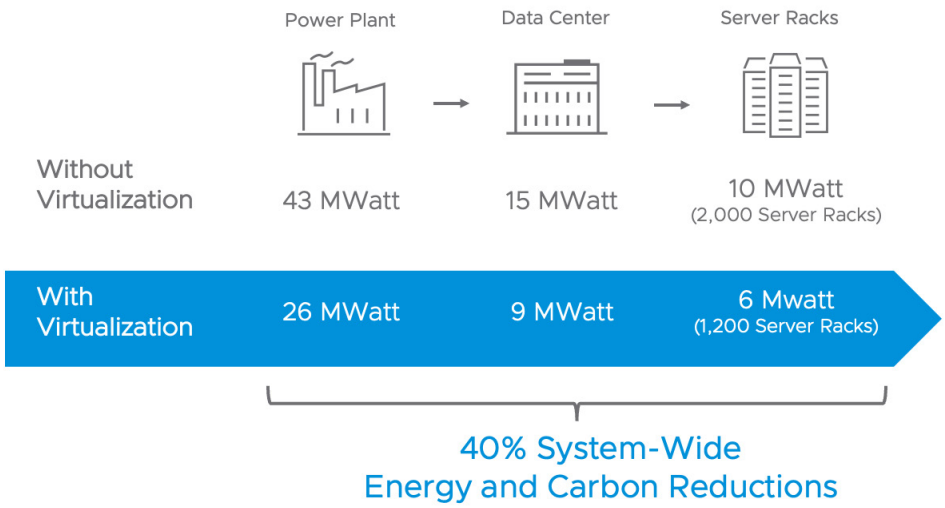


Figure 3: Analyzing the influence of virtualization on energy flow.

These dynamic lifecycle management innovations, all enabled by virtualization, can make data center resources last much longer than they otherwise would. Together, they offer highly effective tools to reduce overall power consumption and e-waste in CSP data centers.

Saving Energy with RAN Intelligent Controller Applications

One of the more exciting innovations to come with *new open RAN architectures* is the *RAN Intelligent Controller (RIC)*—a distributed software platform built right into the RAN that can run internal and third-party applications. RIC rApps and xApps can deliver a variety of new capabilities and operational intelligence right at the point of connectivity to the network. As an early RIC innovator, VMware and our partners are developing several such innovations—including new rApps and xApps to optimize power efficiency.

Recently, VMware developed a Traffic-Based RAN Energy Saving rApp that's currently in trial with several CSP customers. The rApp monitors traffic load across the network, and then idles or shuts down sectors of a cell site when no traffic is going through. When traffic is light (such as at night), the rApp deactivates some cells in the network's capacity layer—reducing energy consumption and waste—while preserving the coverage layer. Then, as traffic ramps up, the rApp progressively reactivates capacity layers. Some RAN equipment providers offer similar capabilities today via software features, but these changes can only activate within specific time intervals. With VMware's Traffic-Based RAN Energy Saving rApp, CSPs can employ these smart power interventions continually, almost in real time.

This is just one example of the vast potential of RIC intelligence to improve energy and resource efficiency in CSP networks. Other emerging smart energy capabilities enabled by VMware RIC include the following:

- **Radio Unit (RU) energy-saving features** (depending on RU capabilities) that can switch off components, such as power amplifiers, when no transmission is required
- **Multiple-Input, Multiple-Output (MIMO) intelligence** that can turn off some MIMO branches and send traffic through remaining ones (switching from four branches to two, or even two to one) when utilization dips below certain thresholds
- **Cell sleep modes** that lock cells during periods of low traffic
- **Band-steering intelligence** to move traffic to the most energy-efficient band (for example, shifting from 4G to 5G when 5G coverage and penetration is high enough, which consumes as little as one tenth the power)

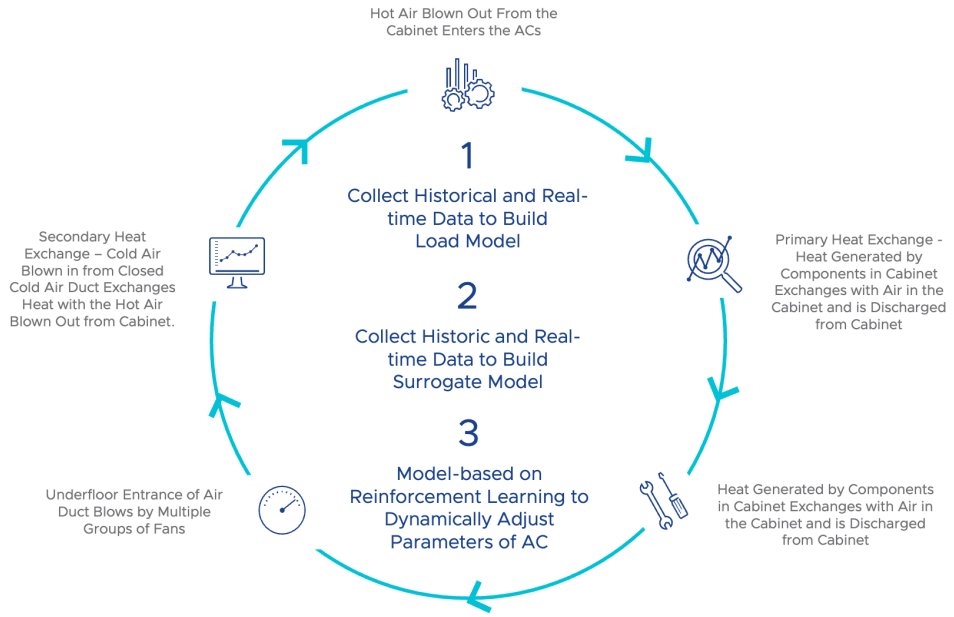


Figure 4: Deep Cooling in the Right Place, at the Right Time.

Any one of these RIC innovations can reduce energy consumption in a CSP network. Together, they can add up to huge energy savings. That's especially true when combined with emerging Artificial Intelligence and Machine Learning (AI/ML) strategies—for example, applying advanced traffic prediction models to move traffic across the network based on resource utilization.

Analyst ACG has created a comprehensive model to analyze power savings from Open RAN, RIC, xApp, and rApp solutions from VMware. The baseline savings from *VMware Telco Cloud Platform RAN* innovations: 30% Total Cost of Ownership (TCO) savings over three years.

Reducing Data Center Power Consumption with Deep Cooling

As the size and number of data centers has grown, their energy consumption has grown too—creating a significant sustainability challenge for everyone relying on them, including CSPs. According to some estimates, the world's data centers consumed as much as 400 terawatt-hours (TWh) in 2020, equivalent to 2% the world's total energy consumption.[11] In response, VMware and other ICT leaders are working to develop new strategies for more sustainable computing.

VMware is working with Intel and Quarkdata on a joint solution, called Deep Cooling, to accelerate carbon-neutral compute technologies. Deep Cooling's AI-driven solution can help optimize power consumption and performance of data center cooling systems through continuous edge intelligence and real-time interventions. The solution uses Big Data and AI technologies to model various physical systems in large data centers, such as power load, heating, and cooling. It uses the insights gained from this modeling to predict the results of changing loads, and automatically adjust equipment parameters to optimize cooling systems (see Figure 4). Deep Cooling is now implemented in several large Chinese data centers, where it's helping customers significantly improve power usage effectiveness and reduce carbon emissions.

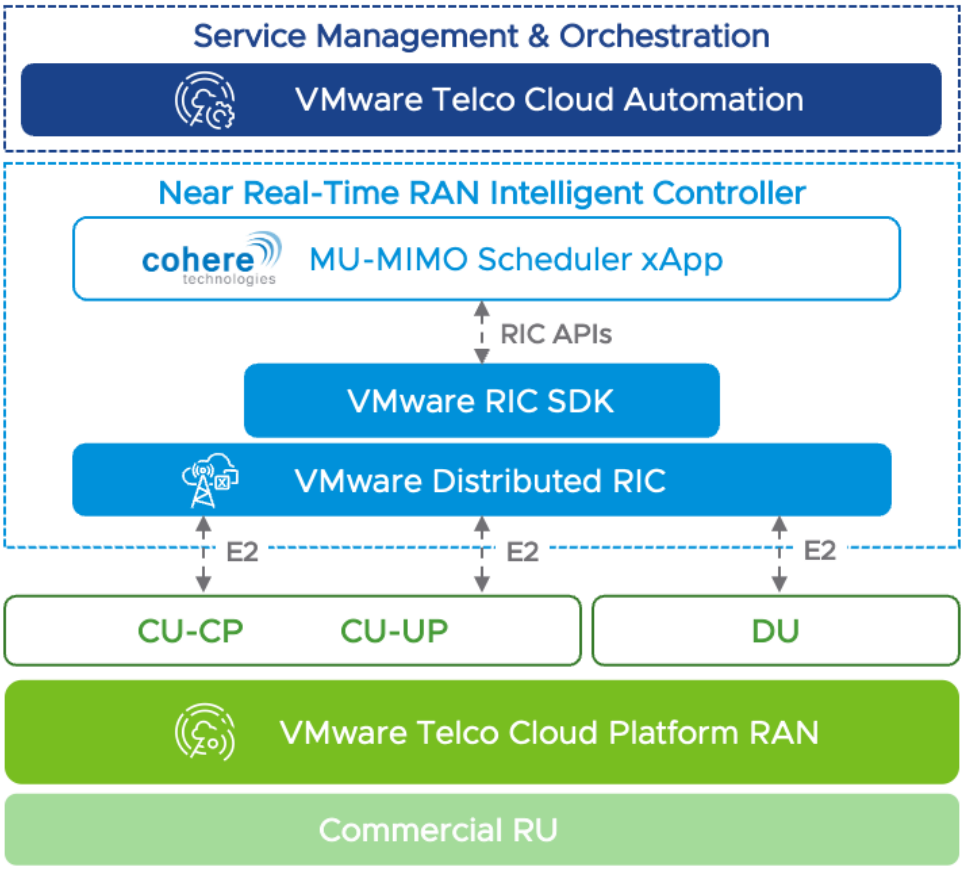


Figure 5: Spectrum efficiency yields power savings. Cohere's Spectrum Multiplier xApp runs on VMware RIC.

Improving Spectrum Efficiency

Power isn't the only resource that telco networks could use more efficiently. For Mobile Network Operators (MNOs), radio spectrum is among the industry's most precious resources. If MNOs could get more out of their existing spectrum, they could not only improve energy efficiency, but they could also realize significant economic benefits too. Now, VMware is working with Cohere Technologies to do just that.

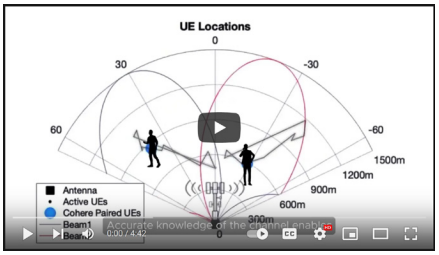
Cohere's Spectrum Multiplier xApp, running on the VMware RIC, uses signal sampling and a novel Multi-User MIMO (MU-MIMO) scheduler to use available spectrum more efficiently. In real-world deployments, this solution has delivered a *1.3-2x improvement in spectral efficiency*. This improvement yields multiple benefits, including increasing the life of a CSP's existing assets and reducing e-waste. But it also makes a big difference in an MNO's overall energy efficiency, delivering up to **double the spectral capacity for about the same electricity investment**.

Responding to Shortage and Outages

VMware has created several solutions and programs to help CSPs quickly recover from outages and best operation through shortages.

- Load Shedding - Power down virtual machines and hosts to reduce service levels.
- Green Load Balancing - Respond to power system without impacting workloads by dynamically balancing the load.

RIC VIDEO DEMONSTRATION: SUSTAINABLE BROADBAND



Activating Sustainable Broadband with VMware RIC and Cohere Technologies

VIDEO: VMWARE GREEN ENERGY HIGHLIGHTS

YouTube video featuring VMware green energy highlights.

VMWARE ZERO-CARBON INNOVATION IN ACTION: ESB

Using VMware Aria and Blockchain, Ireland's leading energy utility, ESB, is helping cloud providers reduce energy consumption in their data centers by auditing renewable energy sources for their customers. This project could have far-reaching implications, as Ireland's grid supports the most hyperscale and other larger data centers in Europe—which consume more than 20% of the country's energy.

In response to tightening E.U. regulations, end customers of these large cloud providers want detailed measurements of the emissions their workloads generate, as well as the ability to demonstrate that they're using green energy from the grid. VMware is helping ESB enable such auditing, along with new capabilities to shift workloads to times and/or locations where more green energy is available. If successful, this project is highly repeatable in other national grids, and ESB is already communicating with power companies across Europe and the United States to share these innovations.

- Proactive Disaster Recovery as a Service (DRaaS) - Re-start workloads in remote regions and replace on-prem backup infrastructure with on-demand cloud-based backup capacity. On-demand backup capacity without the data center also helps customers reduce 45% carbon emissions per year.

Using Renewable Energy Sources

One of the most effective ways to reduce carbon emissions is to reduce our dependence on energy generated from carbon-intensive sources. But while innovations in renewables have exploded in recent years, we still have a long way to go. As of 2018, more than two thirds of the world's electricity was still generated from sources like coal and natural gas.[12]

Transitioning to 100% renewable power will require a significant global effort that extends well beyond the ICT industry. In the meantime, however, individual companies can still achieve meaningful gains by powering more of their own operations from renewable sources. ICT leaders like VMware are helping them do it. First, we're demonstrating what's possible with our own actions, *sourcing 100% of the electricity for our global operations from renewable sources*. But we're also developing new strategies to help our customers adopt more intelligent, carbon-aware resource management.

Shifting Workloads to Renewable Sources

Many CSPs and other large network operators would prefer to use more renewable energy, but renewable sources like wind and solar can't necessarily be relied upon at all times, in every location. A more practical short- and medium-term solution would be to use a mix of power sources, with the ability to prioritize renewables when possible. For this strategy to be successful, however, we need tools that can identify the availability of renewable energy sources across multiple national or global facilities, and intelligently shift workloads in response.

On the surface, systems like these would seem to require radically new technology capabilities. In practice, however, they operate very similarly to the Disaster Recovery (DR) tools organizations use today to shift workloads to different data centers in response to an outage. As a longtime innovator in data center DR, VMware is in excellent position to lead the effort to develop these types of intelligent systems. Drawing on our extensive DR knowledge and technology, we're developing new tools to help organizations increase their utilization of renewable power sources, respond more effectively to power grid fluctuations, and improve overall energy efficiency.

VMware is developing a *new green load balancing solution* that tracks carbon density/renewable resource data and uses it to make smarter workload placement decisions. Implemented in *VMware Telco Cloud Platform*, the solution turns infrastructure telemetry into end-to-end AI-for-Operations (AIOps) tool for the data center, enabling context-aware resource allocation. Early trials suggest that this kind of intelligent workload placement and migration could help CSPs **reduce RAN network emissions by up to 52%**.

Solutions like these will help CSPs, cloud providers, and other large ICT users ramp up their use of renewable energy and reduce emissions—as well as respond more effectively to power fluctuations in the grid—using proven DR tools and procedures they already trust.

VMware virtualization innovations from 2003 to 2019 have resulted in:[13]

- Organizations worldwide deploying more than 142 million fewer physical servers
- Cumulative energy savings of nearly more than 1.5 billion megawatt hours (MWh) from IT infrastructure avoidance
- Total avoidance of 1.2 billion metric tons of CO_2 emissions (In 2019 alone, emissions avoided from VMware virtualization equated to removing nearly 33 million cars from the road.)

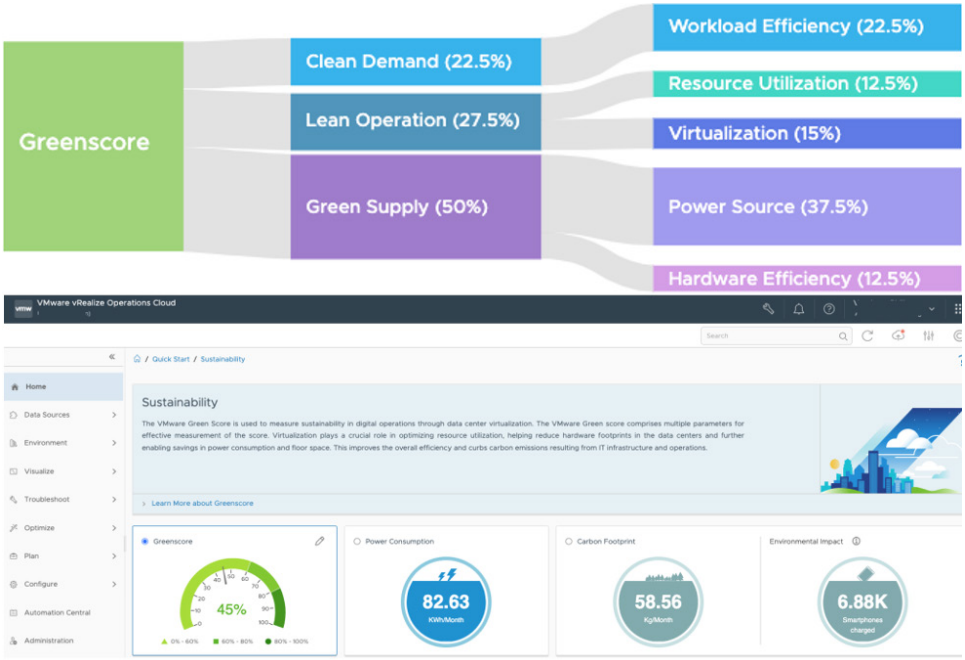


Figure 6: VMware provides emissions scoring.

We're using the same green innovations to reduce emissions within VMware as well, employing virtualization and containers to reduce the hardware needed to operate and grow our business operations. In 2019 (our fiscal year 2020), VMware cut our emissions intensity by 46% over the previous year, even as we grew total revenue by 12%.[14]

Helping Telcos Automate

CSPs worldwide are adopting Telco Cloud architectures to support emerging 5G infrastructures. These new cloud architecture and operating models enable much more agility and flexibility, but they can also make telecom network operations far more complex. We're helping to simplify next-generation CSP operations with VMware Telco Cloud Automation™, our virtualized, horizontal platform for network orchestration and automation.

Among other capabilities, VMware Telco Cloud Automation streamlines the packing of virtualized and containerized Network Functions (xNF) onto servers, helping customers reduce the time it takes to deploy cell sites by *as much as 80%*. With these innovations, we're helping CSPs reduce the truck-rolls they need to expand their 5G rollouts and manage their ongoing operations.

Tracking Emissions

To solve a problem, you first have to be able to measure it. This has long been the biggest barrier in reducing the Indirect carbon of ICT infrastructure—the lack of tools and data to measure Indirect emissions. VMware is working to change that.

In *VMware Aria Operations* (formerly vRealize Operations), we provided the first *sustainability dashboards* to show how much carbon emissions are saved by compute virtualization, and to help businesses identify idle workloads to optimize their carbon footprint. Today, organizations can use these tools in the data center to measure electricity consumption and track Scope 2 emissions. Aria Operations also now includes a *VMware*

Green Score to measure emissions and energy efficiency within VMware's sphere of influence. This tool offers an excellent starting point for organizations to track their decarbonization journey and measure their progress over time. Similarly, *VMware Workspace ONE* now includes tools to help businesses understand emissions from endpoint devices connected to the network, as well as to reduce e-waste.

Today, CSPs (and any other large business) can use these capabilities to begin tracking Indirect emissions for their data centers and endpoint devices. In the future, these capabilities may extend to the telco infrastructure itself.

Overcoming Institutional Barriers

The ongoing innovation we're seeing in green technology are nothing short of amazing. But in some ways, technology is the easy part of the problem to solve. Often, the biggest barriers to a zero-carbon future are much more human: culture, policy, processes, lack of focus or funding, and just simple resistance to change. The good news is that more business and industry leaders recognize the challenge posed by these social and institutional barriers to sustainability. And leading companies like VMware are working with partners around the globe to help break them down.

To achieve zero-carbon goals, the service provider industry—like every other industry—needs leaders who can communicate a clear vision of what a more sustainable future looks like. CSPs need clear guidance on how they can balance business requirements and technical capabilities with sustainability objectives, and effective strategies to set goals and measure progress in achieving them. Here again, VMware is among the most important voices in this industrywide conversation.

VMware technologists and policy experts are playing key leadership roles in many of the industry groups shaping zero-carbon initiatives for service providers. Through these groups and alliances, we're helping to develop best practices, tools, metrics, and standards to enable more sustainable ICT software, hardware, and processes. Examples include:

- *Next Generation of Sustainable Digital Infrastructure*: Through an ongoing collaboration between VMware and the U.S. National Science Foundation (NSF), we've jointly created this new research program with the goal of minimizing the ICT and data center infrastructure needed to support the world's digital workloads. The program works with academic research groups to develop novel metrics, measurement tools, architectures, and management approaches to foster more sustainable digital infrastructure.
- *Zero Carbon Committed Initiative*: The initiative promotes our public cloud providers that are committed to achieving 100 percent renewable energy-powered data centers by 2030 and connects them with our customers who have net zero goals. Since the program's launch, we have partnered with 30 public cloud providers, including Google, AWS, Oracle and many more.
- *VMware Environmental and Social Governance (ESG) Team*: Focused on creating solutions and initiatives to meet our ESG goals as well as help our customer's reach their goals, the ESG team is a valuable resource. They published the ESG Report and 2030 Agenda, and continue to co-innovate with our customers and partners.
- *Green Software Foundation (GSF)*: VMware plays an active role in this nonprofit, which aims to promote the importance of sustainable software across the tech industry. Working with participants from Microsoft, Accenture, GitHub, NTT DATA, and many others, we're helping to build a trusted ecosystem of people, standards, tooling, and best practices for "green software." For example, the group sponsored *Carbon Hack 2022*—a race to build the most innovative carbon-aware software solutions.
- *Next G Alliance*: VMware is a founding member of the Alliance for Telecommunications Industry Solutions (ATIS) Next G Alliance, an initiative led by North American wireless

technology leaders and CSPs to help shape the future of the industry. As part of this work, VMware is helping to lead the *Green G Working Group*, which focuses on reducing the energy consumption and environmental impact of tomorrow's wireless technologies.

- *Clean Energy Buyers Association (CEBA)*: VMware is a board member and active participant in CEBA, working to build a more resilient zero-carbon energy system, where every organization has a viable, expedient, and cost-effective pathway to renewable energy.
- *RE100 Climate Group*: VMware is a proud signatory to RE100, a global collaborative representing businesses committed to using 100% renewable electricity.

Looking Ahead

The environmental challenges facing the ICT industry—and due to our dependence on digital networks and technologies, facing the world—remain significant. We will need a concerted, long-term effort from organizations around the globe to overcome them. Fortunately, visionary technology leaders from across the ICT industry are working to do just that. VMware is proud to be playing a key role in developing a new generation of solutions, policies, and industry collaborations to advance ICT sustainability. Together, we can steadily move our industry and our planet towards a zero-carbon future.

To learn more, visit our *communications service provider network modernization website*.

LEARN MORE

For more information about sustainability solutions for telcos from VMware, call 1-877-VMWARE (outside North America, dial +1-650-427-5000) or visit *https://telco.vmware.com/*

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