Executive Summary

Green IT: Virtualization Delivers Energy and Carbon Emissions Reductions

Sponsored by: VMware Inc.

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October 2016

IDC OPINION

The introduction of virtualization software for x86 servers opened an era of server consolidation and increased operational efficiency through a reduction in the number of servers deployed and an increase in the utilization rates of servers deployed with virtualization software. Led by VMware, which delivered the first widely adopted x86 server virtualization software, this industry transition has been particularly attractive for large enterprise users.

In the late 1990s and early 2000s, x86 servers were deployed en masse — often at excessively low levels of utilization. The hardware was growing in capacity faster than customers were able to extract value. Virtualization helped rightsize and counteract this disparity between CPU, memory capacity, and utilization. Virtualization also served as a catalyst to help larger customers contain and begin to reduce their server sprawl. Datacenter expansion was mitigated, fewer servers were deployed, and utilization rates started to increase to more acceptable levels.

For most customers, the direct benefit of this change in trajectory was a sharply reduced spend on new servers, which was offset only modestly by the license or subscription costs for the virtualization software itself. Associated "green" benefits, which some customers cited as part of their social responsibility efforts, added to the value proposition. In reality, the green benefits, though admirable, were less likely to justify spending if there had not been an immediate and highly tangible return on the investment to virtualize the datacenter — which there was. In aggregate, virtualization software has had a dramatic effect on lowering the number of servers needed in the market. This IDC Executive Summary evaluates the impact that VMware virtualization software has made on power consumption and associated carbon dioxide (CO_2) emissions and calculates a value for the power consumption and CO_2 emissions that were avoided because of server virtualization and consolidation. Key observations include the following:

- Server virtualization has positively impacted the industry by enabling customers to reduce server acquisition and life-cycle costs, reducing datacenter space requirements and most importantly reducing power consumption, cooling, and management demands.
- Reduction of power consumption has a direct effect on the environment, reducing the release of greenhouse gases from power generation and aiding corporate social responsibility initiatives.
- The benefits associated with server consolidation will continue to accrue for many years into the future and are augmented by reduction in cooling energy consumption and related datacenter equipment that is not needed because of a smaller server count in use.

METHODOLOGY

IDC used a conservative and defensible approach to calculating the power consumption avoided and associated carbon dioxide emissions that were avoided because of the industry's use of VMware virtualization software. Where possible, we used published IDC data as the basis for the secondary calculations.

IDC started with published data from IDC's Worldwide Server Tracker and IDC's Worldwide Quarterly Server Virtualization Tracker. This data was used to establish the number of physical servers, including those running without a hypervisor and those deployed with a VMware hypervisor product, for the years 2008–2015.

IDC then extended that data model back to 2003 for the purpose of establishing the number of servers deployed with VMware hypervisors during the early years of x86 virtualization adoption. By multiplying the number of servers deployed with virtualization software by the average virtual machine density, we established the number of virtual machines that were put into service each year between 2003 and 2015.

The resulting new deployment data was then aggregated using installed base calculations to determine cumulative server counts for deployments that were assumed to be avoided. The count of servers not deployed and the installed base totals derived from the count of servers not deployed were then multiplied by average power consumption rates to determine megawatt hours (MWh) avoided, which were also converted into pounds of carbon dioxide emissions avoided.

A fully detailed methodology is included in the Appendix section at the end of this document.

SITUATION OVERVIEW

Virtualization software makes it possible to reduce the number of physical servers used by consolidating multiple server operating system instances and their associated workloads on a smaller number of physical servers. Reducing the number of physical servers in use leads to an associated savings in datacenter floor space and power consumed by the server installations that have been avoided. In addition, there is often a reduction in cooling system power consumption as well, although power consumption associated with infrastructure was not considered as part of the calculation presented in this IDC Executive Summary.

Figure 1 presents IDC's calculation showing two pieces of data:

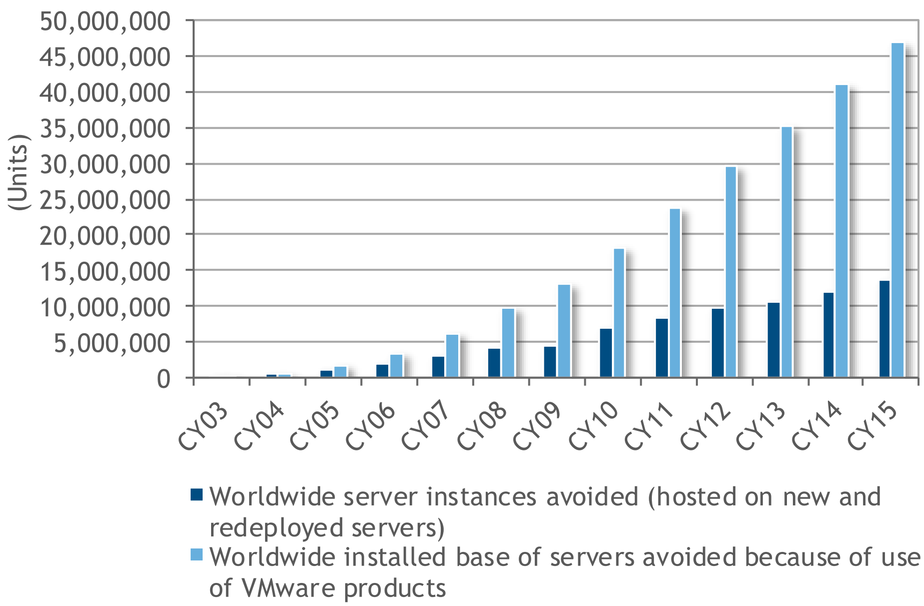
- Annual server instances worldwide avoided because of the use of new server shipments virtualized and annual existing installed servers newly redeployed with hypervisors (combined) (This constitutes the entry of new virtualized instances or, in this document, "servers avoided" each year.)
- Installed base of servers worldwide avoided annually

As indicated in Figure 1, annual servers avoided because of the use of VMware virtualization products grew from a combined total of 107,000 in 2003 to 13.8 million in 2015.

Figure 1 also shows the installed base of the server shipments avoided. That total grew from 107,000 in 2003 to 47 million in 2015. The totals shown in Figure 1 serve as the basis for calculating the amount of power and CO_2 avoided because of the use of VMware virtualization products.

FIGURE 1

Worldwide New Server Shipments Avoided and Installed Base of Servers Avoided Because of the Use of VMware Server Virtualization Software



Source: IDC, 2016

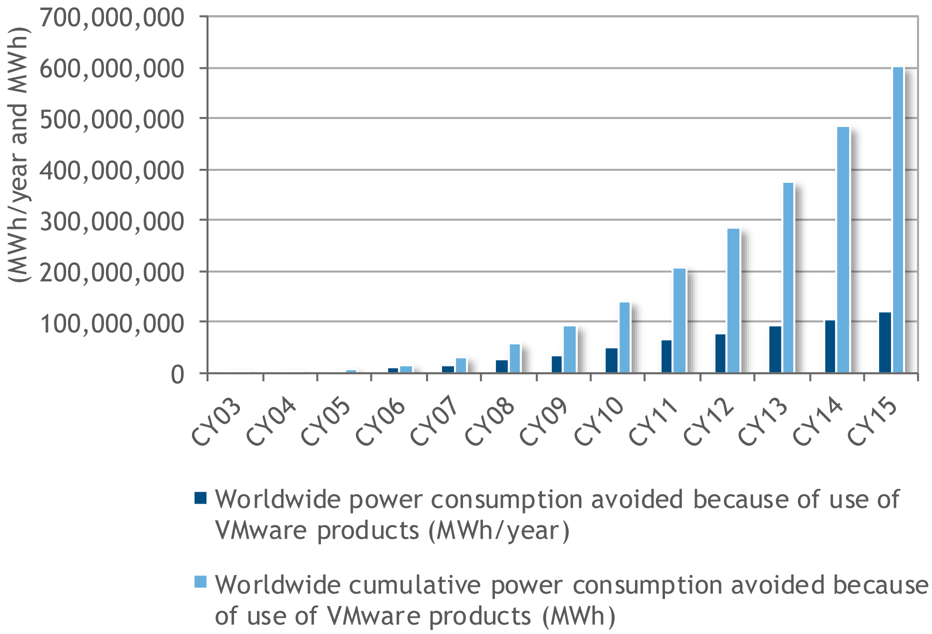
The Benefits of Virtualization in Reducing Power Consumption and CO_2 Emissions

The notion of power consumption avoided is directly related to the avoidance of new server deployments because of the use of virtualization software. Figure 1 presents the calculated number of servers that were avoided because of the use of VMware virtualization software. By multiplying the number of servers avoided by the average power consumption and number of hours of use per day those servers would tally (if they were real servers that were placed into service in a datacenter), we can calculate the number of MWh avoided directly because of the workloads that have been consolidated on VMware virtualization products.

Figure 2 shows worldwide power consumption avoidance associated with the use of VMware server virtualization products. Power avoidance grew from 191,000 MWh in 2003 to 120 million MWh in 2015. From a cumulative total, the power consumption savings grew from 191,000 MWh in 2003 to 603 million MWh in 2015. To put some perspective on that total, 603 million MWh of cumulative power consumption avoided is equivalent to the power consumed by 43% of total U.S. households for one calendar year (during 2015 per U.S. Census data). The savings from virtualization software is magnitudes of order beyond what can be delivered by incremental improvements in efficiency that come from more efficient processors, more efficient power supplies, or a move from spinning media to solid state storage.

FIGURE 2

Worldwide Power Consumption Reduction Associated with the Use of VMware Products



Source: IDC, 2016

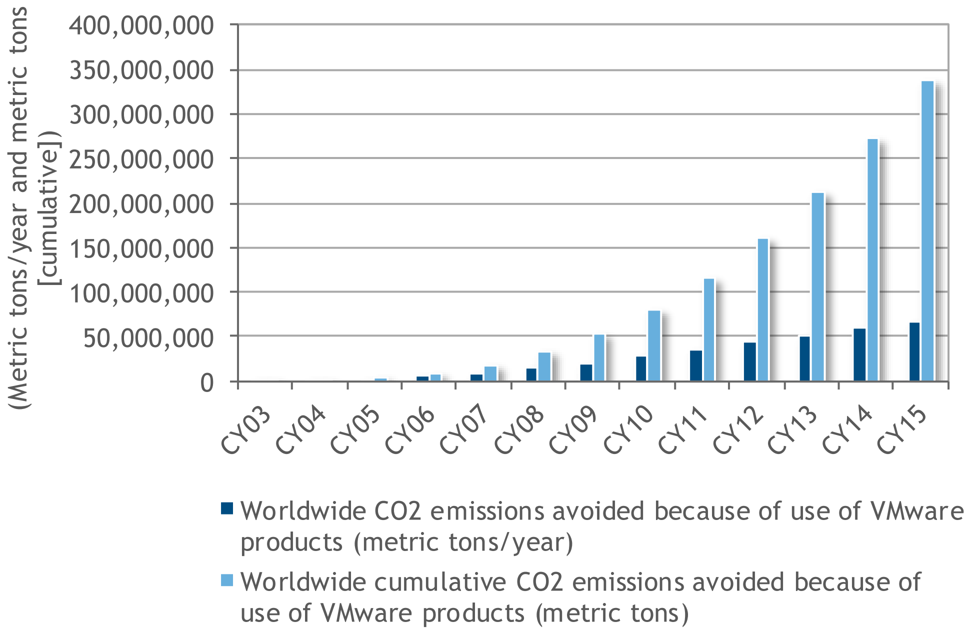
Figure 3 presents the CO_2 emissions reduction related to the use of VMware server virtualization products. Figure 3 is calculated by multiplying the average number of metric tons of CO_2 produced by the number of MWh produced annually and cumulatively.

As noted in Figure 3, CO_2 emissions avoided related to the use of VMware server virtualization products grew from 107,000 metric tons/year in 2003 to 67 million metric tons/year in 2015. In terms of cumulative emissions, avoided emissions grew from 107,000 metric tons in 2003 to 339 million tons in 2015.

The CO_2 avoidance in 2015 alone is the equivalent of removing 14 million cars from the road and the avoidance of having driven 257 million miles in 2003 and 161 billion miles in 2015. In cumulative terms, 339 million tons is the equivalent of having eliminated 812 billion automobile miles being driven over the past 13 years.

FIGURE 3

Worldwide CO_2 Emissions Reduction Associated with the Use of VMware Products



Source: IDC, 2016

CONCLUSION

It is clear that virtualization software has had a significant, positive effect on lowering the number of servers used in the market.

The data presented in this IDC Executive Summary presents the reductions in power consumption and related CO_2 emissions directly attributed to VMware products in use around the world. VMware is a market leader in server virtualization software, and its products have been and continue to be a major driving force in helping customers realize higher levels of operational efficiencies in their datacenters – resulting in a positive benefit to the planet through reducing CO_2 emissions.

APPENDIX

Detailed Methodology

IDC used a conservative and defensible approach to calculating the power consumption avoided and associated carbon dioxide emissions that were avoided because of the industry's use of VMware virtualization software. Where possible, we used published IDC data as the basis for the secondary calculations.

The methodology applied is as follows:

1. IDC based this model on syndicated (published) IDC data including the following dimensions:
   - IDC's Worldwide Server Tracker data provided the basis for total worldwide server shipments. We used data from calendar years 2003 through 2015 as a starting point for this model.
   - IDC's Worldwide Quarterly Server Virtualization Tracker was the basis for new server shipments virtualized using VMware virtualization. We included all VMware virtualization products including VMware GSX, VMware ESX, VMware Server, and VMware vSphere. IDC's Worldwide Quarterly Server Virtualization Software Tracker provides data from 2008 through 2015. Servers running competitive hypervisors from Microsoft, Red Hat, Citrix, and others were specifically excluded from this analysis.
2. To bridge earlier historical years that predate IDC's Worldwide Quarterly Server Virtualization Tracker, IDC applied assumptions to solve for a complete historical view for the use of VMware hypervisor products on new server shipments virtualized (new servers shipped with a hypervisor installed before shipment, during shipment, or immediately after delivery). Assumptions applied for the period from 2007 back to 2003 were as follows:
   - In 2003, the assumption applied is that VMware was the only viable x86 server virtualization technology in (relative) widespread use. We scaled the overall worldwide penetration of virtualization deployments on new server shipments from 18% in 2008 (reported in IDC's Worldwide Quarterly Server Virtualization Tracker) to 2% in 2003.
   - We scaled VMware's overall share of the worldwide total of new server shipments virtualized from 61% in 2008 to 100% in 2003. (In other words, VMware captured 100% of the 2% of new server shipments that were virtualized in 2003). In 2003, VMware was the only viable virtualization technology on x86 hardware.
   - IDC's working models behind the top-level conclusions produced here were built using detailed dimensions including product type (blade, density optimized, rack optimized, and tower) and socket count (1 socket, 2 sockets, and 4+ sockets).
3. IDC applied the same assumption to bridge from 2007 back to 2003 to develop a complete historical view for the use of VMware hypervisor products on existing installed servers.
4. Virtual machine density (VM density), as reported in IDC's Worldwide Quarterly Server Virtualization Tracker for 2008 to 2015, was scaled back linearly to solve for historical data: The starting point for this model — 2003 — assumes two VMs/new server shipments virtualized.
5. Total instances were calculated by multiplying VM density for new server shipments virtualized and installed base deployments (individually) by their respective unit volume to come up with total instances placed into service each given year.

6. At this point in the model, IDC applied a "discount" to reduce instances from the installed base that may have been the result of virtualization sprawl.
   - The discount applied ranged from 6% of instances in 2003 to 25% in 2015. The presumption is that virtualization software, in conjunction with today's datacenter-oriented virtualization-friendly licensing, makes it easy (and affordable) to spin up more instances than would have happened if a hardware and software purchase was necessary for each individual instance to be created.
7. Installed base of total server instances in use each year was determined by an installed base calculation on the discounted instance total, using a mathematical formula that replicates the calculations for physical server installed base totals produced in IDC's Worldwide Server Tracker database. This calculation is done individually for new server shipment virtualized instances and separately for instances aboard installed base servers that have had hypervisors installed, and varied by form factor. Overall, the average life expectancy for servers included in this study was about 4.5 years.
   - The presumption is that virtualized operating system/workload instances on a server newly deployed will have a life cycle much like that of an existing server installation (because the alternative would have been to install that instance on a dedicated server).
   - Separately, we calculated the life expectancy/installed base for instances aboard installed servers that received a hypervisor through a redeployment midlife; instances running on these servers were assumed to have a considerably shorter life cycle than instances running on brand-new servers.
   - These two separate installed base calculations were combined to produce a total number of server instances that were avoided because of the use of VMware virtualization solutions.
8. The overall total installed base of servers in use were then multiplied by power consumption estimates for each server product type (blade, density optimized, rack optimized, and tower), and by socket count.
   - We used U.S. Department of Energy estimates to help shape the actual power consumed by servers, which tends to be roughly 70% of the rating of the power supply included with the server itself. (Source: http://eta.lbl.gov/sites/all/files/lbnl-1005775_v2.pdf)
   - Power consumption was assumed to be higher in early product years, with efficiency improving each year up to 2015. (Source: http://eta.lbl.gov/sites/all/files/lbnl-1005775_v2.pdf)
9. The results of step 8 were then multiplied by the number of hours of utilization per day those servers experienced.
   - Commercial servers commonly used in large-scale datacenters and cloud environments, including blade, density-optimized, and rack-optimized form factors, were assumed to have a high level of "on time" — between 20 hours and 24 hours — because the result of shutting down servers during low-use periods can be detrimental to the balancing of cooling systems counteracting the heat exhausted from datacenter infrastructure.
   - Density-optimized form factors, commonly used in hyperscale datacenters, were assumed to have the highest uptimes. However, density-optimized servers are not heavily used with VMware hypervisor products because most density-optimized servers tend to run bare metal workloads.
   - However, form factors more likely to have non-datacenter deployments were treated uniquely. Tower form factors are commonly used in small and medium-sized businesses (SMBs) and branch offices and were assumed to have a comparatively short daily "on time" of 12 hours per day. (Source: IDC estimates)
   - The resulting data produced watt hours of power consumed per day and per year.

10. We converted annual power consumption to megawatt hours annually and in turn converted MWh to equivalent CO_2 emissions associated with that power consumption.
    - CO_2 generation rate used is for the overall United States, or 1,238.516lb of CO_2 per MWh of power generated. IDC recognizes that there are differences in global emissions factors and this would be an area for further study.
    - Our assumption is that emerging geographies have higher CO_2 emission rates and mature geographies (such as Western Europe) have lower CO_2 emission rates.
    - The United States accounted for about 34% of new server shipments in 2015, while Western Europe accounted for 19% of new server shipments. Asia/Pacific outside of Japan accounted for 31% of new server shipments in 2015. We used the average U.S. CO_2 emission rate/MWh for the overall worldwide calculation, assuming that higher emission rates (because of the use of inexpensive, high-emission fuels) in the fast-growing emerging market segments will more than offset the lower emission rates of Western Europe. As a result, the U.S. average is a conservative conversion factor to use.
    - (Source: U.S. Census Bureau, http://www.census.gov/hhes/families/data/households.html)
11. The calculation for cumulative power consumption equivalency per household is as follows:
    - 747 billion pounds CO_2 (cumulative) divided by 14,020 pounds CO_2 emission from electric utilization per year per household equals 53,299,638 households' emission for *one* year.
    - 53,299,638 divided by 124,587,000 households total (per U.S. Census data) equals 43%.
12. The calculation for annual CO_2 avoidance per household is as follows:
    - Using MWh: 119,593,970 MWh per year (in 2015) avoided through the use of VMware Virtualization divided by 11.320 MWh per year per household (note that we divide KWh by 1,000 to get to MWh) equals equivalent emissions of 10,564,838 households for one year.
    - Alternatively, we could also arrive at this value using CO_2 released: 148 billion pounds of CO_2 released per year avoided through the use of VMware Virtualization (in 2015) divided by 14,020 pounds of CO_2 released per household per year equals equivalent emissions of 10,564,839 households for one year.

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