# Energy Savings and Usability of Zero-Client Computing in Office Settings

## BETTER BUILDINGS ALLIANCE

Plug loads account for approximately 30% of commercial whole-building energy use, and this percentage is growing.[1] That means the United States spends about $60 billion per year on energy to keep our devices running. About 10% of this is attributed to computing resources,[2] which include both traditional laptop and desktop computers, as well as data centers that can host virtual machines (VMs) and enable teleworking trends. Teleworking and more flexible work environments are becoming increasingly popular options, and many business and building owners wonder whether hosting VMs on data center servers has the potential to save energy. To answer this question, researchers at the National Renewable Energy Laboratory (NREL) conducted a study comparing energy and usability of remote VMs (accessed through zero-client devices) with traditional laptop computers. The findings were published in *Intelligent Buildings International* in September 2018.[3]

As plug-in devices become more prolific and other building systems (such as heating, ventilation, and air-conditioning systems) become more efficient, it is increasingly critical to focus on reducing plug-load energy consumption. In the computing world, remote VMs have the potential to provide plug-load energy savings as well as improve mobility, simplify network management, and increase cybersecurity. They also provide an economy of scale, because computing resources are managed and maintained at the data center level. These benefits support the emerging shift toward more flexible work environments.

## Zero Clients—What Are They?

Remote VMs are often accessed through "zero-client" computing devices, which are devices that have no local storage, memory, or processing ability, but project a server-based VM onto a connected display. A user's VM can be accessed through the zero client or through additional devices such as laptops, tablets, or even smartphones—enabling a user to access the same machine from multiple locations or devices.

## Zero Client Performance and Applicability

To assess the energy and usability differences between zero-client and laptop computing systems, NREL used submetered plug-load energy data from NREL's Research Support Facility to compare the power consumption, usability, and applicability of both computing systems in the workplace.[3] A few key findings are explained below.

**Zero clients can reduce computing power at the workstation by approximately 16% when workers are at their workstations, as compared with laptop computers.** However, these savings only apply to businesses that use cloud-computing services where VMs are stored on remote data center servers. If a business uses its own data center servers to host the VMs, the data center energy must be accounted for in the total energy savings.

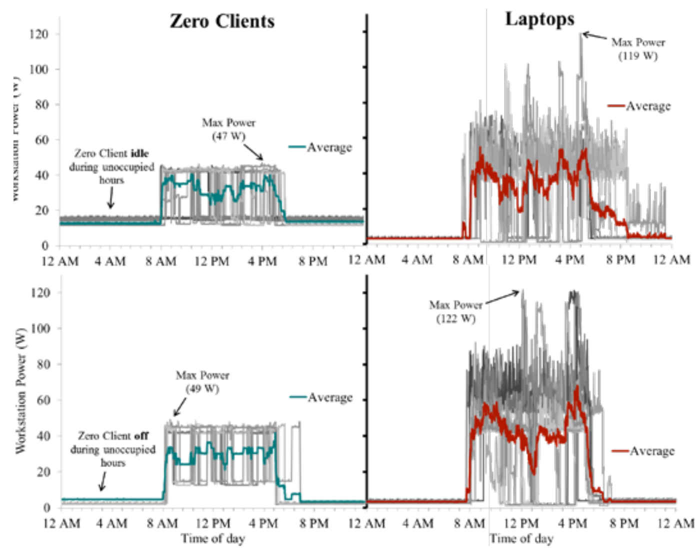


*Figure 1. The electricity consumption of two zero-client workstations compared with two laptop workstations over a 2-week study. These graphs highlight the energy savings that can be achieved when workers are at their workstations.*

**Power management of zero clients may not be as advanced as that of laptop computers.** Zero client devices used in this study consumed 13.74 watts (W) when in an idle state. When powered off, the zero client used only 2.37 W. Thus, it is important

1 U.S. Department of Energy (DOE) 2010. 2010 *Buildings Energy Data Book*. Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. https://www.afdc.energy.gov/pdfs/51680.pdf.

2 U.S. Energy Information Administration (EIA). 2012. Commercial Buildings Energy Consumption Survey (CBECS). Table E3. Electricity consumption (Btu) by end use, 2012. http://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/e3.php.

3 A. Farthing, M.R. Langner, and K. Trenbath. 2018. "Energy savings and usability of zero-client computing in office settings." *Intelligent Buildings International*. DOI: 10.1080/17508975.2018.1513357

that zero clients are powered off when not in use. Regardless of the powered-down state, the VM remains idle, running on the data center's servers, which can help avoid data loss and allows more streamlined updates and backups.

**Workstation energy is not the only energy to consider in zero-client systems.** A zero client depends on a central server to host a VM for computation and storage capabilities—this is called the virtual desktop infrastructure (VDI). In this study, the VDI energy consumption added more than 20 W to the energy consumed by the zero client at the workstation, causing the zero client to use more energy than a laptop computer. However, the VDI machines in this 2016 study were older, and newer, more efficient machines would reduce this added energy. Additionally, data center technology is continually advancing, and technologies such as dynamic reallocation of VMs are capturing energy savings over traditional VM allocations.[4] Table 1 shows results from this study, and the blue row shows the difference in total server-based power required for VM computation between older (current) and newer (future) servers.

**Data center efficiency must be considered.** Server energy affiliated with the VDI should be multiplied by the data center efficiency, which is calculated by the data center power usage effectiveness (PUE). PUE is a ratio of the total data center facility power to the information technology equipment power. An average PUE value is around 2.0.[5] However, the Research Support Facility data center PUE is only 1.16 because of many implemented energy-efficiency strategies.[6]

**Zero clients are most appropriate for light and medium computer-power users.** Power users—computer users that frequently use compute-intensive software and require graphics processors or software to run large simulations—tend to prefer laptop or desktop computers. In this case, they can choose processing speeds, storage capacity, and display resolutions based on their computational needs. Additionally, laptop and desktop turnover is relatively fast, because computing technologies change at such a rapid pace and new and faster machines are always available on the market. Data center equipment turns over at a much slower rate. Unless VMs are stored on very small, closet data centers, it is often too costly and time-intensive to update data center servers at rates that are competitive with the personal computer market. Thus, VMs that operate on older servers can be slower and use more energy than current laptop computers, as shown in this study. That said, for light and medium computer-power users, VDI environments offer advantages that could outweigh slower processing speeds and higher energy use. As previously stated, those advantages include improved mobility, simplified network management, and increased cybersecurity. Project goals should dictate whether the VDI environment is appropriate for business missions, whether it uses older or newer servers, and whether the data center is located in-house.

Table 1. Virtual Machine Power Consumption in the Research Support Facility Data Center as of 2016

| | Current Average | Current Max* | Future Average | Future Max* |
|---|---|---|---|---|
| Power per Blade Server (W) | 215 | 215 | 229 | 229 |
| # VMs per Server | 25 | 40 | 80 | 100 |
| **Power per VM for Computation (W)** | **8.6** | **5.4** | **2.9** | **2.3** |
| Total EqualLogic Storage Power (W) | 1,898.5 | 1,898.5 | – | – |
| # VMs in VDI | 200 | 200 | – | – |
| **Power per VM for Storage (W)** | **9.49** | **9.49** | – | – |
| Total Server-Based Power per VM (W) | 18.1 | 14.9 | – | – |
| Data Center PUE | 1.16 | 1.16 | – | – |
| Total Server-Based Power per VM (W) | 20.99 | 17.25 | – | – |

*Refers to maximum possible VMs on one blade server

4 Beloglazov, A., and R. Buyya. "Energy Efficient Allocation of Virtual Machines in Cloud Data Centers." Paper presented at the 2010 10th Institute of Electrical and Electronics Engineers (IEEE)/Association for Computing Machinery (ACM) International Conference on Cluster, Cloud, and Grid Computing, Melbourne, Australia, May 17–20, 2010. pp. 577–578. http://doi.org/10.1109/CCGRID.2010.45.

5 Lintner, W., B. Tschudi, and O. VanGeet. 2011. *Best Practices Guide for Energy-Efficient Data Center Design*. U.S. Department of Energy (DOE). Accessed July 18, 2016. https://energy.gov/sites/prod/files/2013/10/f3/eedatacenterbestpractices.pdf.

6 Sheppy, M., C. Lobato, O. VanGeet, S. Pless, K. Donovan, and C. Powers. 2011. *Reducing Data Center Loads for a Large-Scale, Low-Energy Office Building: NREL's Research Support Facility*. Golden, CO: National Renewable Energy Laboratory. NREL/BK-7A40-52785. http://www.nrel.gov/docs/fy12osti/52785.pdf.