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ISSUE BRIEF

SLASHING ENERGY USE IN COMPUTERS AND MONITORS WHILE PROTECTING OUR WALLETS, HEALTH, AND PLANET

Computers are indispensable to our economy and our daily lives. Roughly 300 million computers are in use in the United States—almost one for every man, woman, and child nationwide—and their electricity consumption adds up to $10 billion annually, ranking them among the biggest energy users in the electronics category. Keeping them running requires the equivalent of 30 large (500-megawatt) power plants generating electricity around-the-clock every day of the year while emitting 65 million metric tons of carbon dioxide (CO_2) pollution.[1,2] Yet there are no minimum energy efficiency standards at either the state or the national level requiring that these ubiquitous machines be designed to use energy efficiently. This is particularly important for desktop computers which use the most energy and often stay on 24/7 even when no one is sitting in front of them.

Using current technology to make all computers and monitors just 30 percent more energy efficient could save U.S. consumers $3 billion annually and avoid the need to generate 29 billion kilowatt-hours of electricity each year—more than is consumed by all the households in Indiana, or Los Angeles and Phoenix combined. It also will keep 20 million metric tons of carbon pollution out of the air, all with zero impact on computer performance or user convenience.[3] NRDC and its partners developed a demonstration prototype that shows energy use can be cut in half using existing off-the-shelf components, and at minimal added cost.

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While pressure to reduce price tags and manufacturing costs may tempt computer makers to forego energy efficiency, the initial consumer savings at the cash register are rapidly offset by the extra cost of the energy guzzled by these inefficient machines. By reducing the cost of operation, energy efficiency standards put money back in computer owners' pockets, including those of low-income households who spend a disproportionate share of their income on electricity bills, and businesses who use the majority of desktop computers.

There is a common misconception that computers have become so efficient that they offer little remaining opportunity to save energy in a cost-effective manner. The reality is that while there have been great advances in the energy efficiency of computer integrated circuits (chips), these advances have not always been harnessed to minimize the overall energy consumption of the computer system. This is especially true in desktop computers, whose manufacturers have few market incentives for minimizing energy use because desktops are always plugged into an electrical outlet. Many opportunities remain to cut computer energy use substantially, by half or more in some cases, through low-cost hardware and software changes. NRDC partnered with the electronics power-management expert firm Aggios and the California investor-owned utilities to demonstrate these opportunities on a prototype, as described in this issue brief.[4,5] We found that some efficiency improvements would cost only pennies per computer.

Minimum efficiency standards are needed to ensure that all computers and monitors sold in the United States take advantage of readily available technology to cut energy use. The California Energy Commission (CEC) and the U.S. Department of Energy (DOE) are developing the first mandatory standards for computers and monitors in the United States, and international jurisdictions such as the European Union (E.U.) are updating their standards. Meanwhile, the U.S. Environmental Protection Agency (EPA) is about to revise and strengthen the requirements that computer manufacturers must meet in order to use the ENERGY STAR® label to differentiate their more efficient products.

This issue brief explores the various energy- and cost-saving opportunities in computers and monitors, and discusses the need for minimum efficiency standards to ensure these machines are not wasting electricity.

COMPUTER ENERGY EFFICIENCY MATTERS

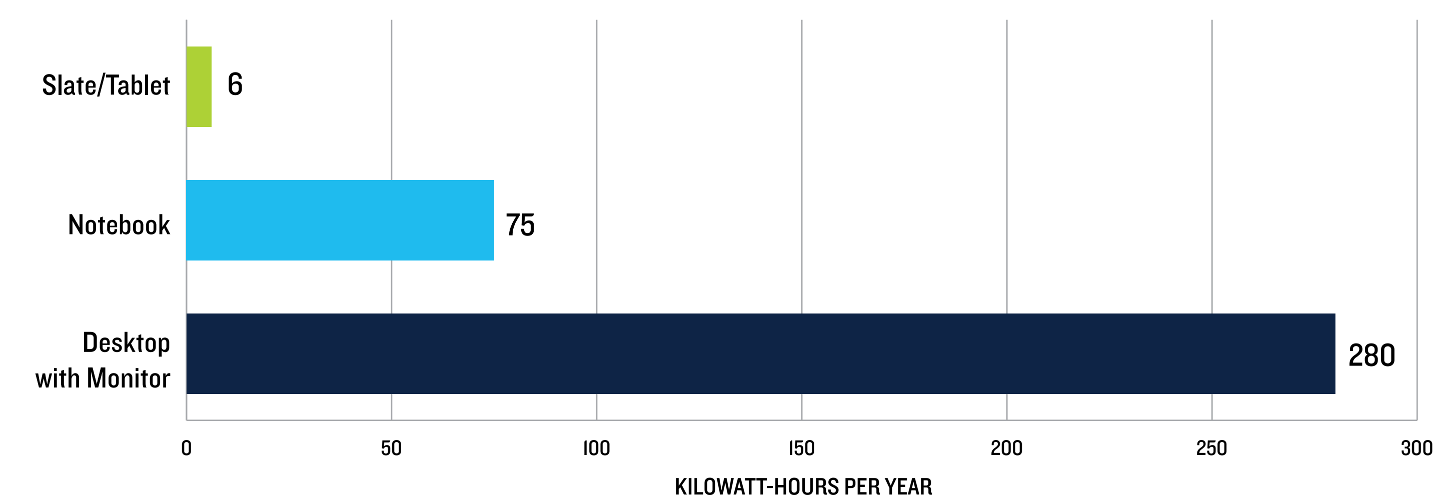
Computers, and the monitors connected to them, rank among the biggest energy guzzlers in America's homes and businesses. Failing to reduce their energy use has large negative impacts nationally. Computer and monitor electricity consumption in U.S. homes and businesses is estimated to total 95 billion kilowatt-hours annually, more than the electricity use of all the households in the state of California each year.[6,7]

Computer chips have become dramatically more efficient over the past decades. While portable devices such as laptops and tablets typically are designed to maximize efficiency and how long they can operate before running out of battery power, the energy use of desktop computers has seen only limited improvement because they have access to virtually unlimited electricity from wall outlets. Manufacturers have had few market incentives to implement energy efficiency best practices. After all, the user, not the manufacturer, pays the electric bill. Unfortunately, consumers can't tell how much of their monthly bill is due to the computer and how much money a more efficient computer would save them.

As shown in Figure 1, a typical desktop and monitor consume roughly four times as much energy as a typical notebook computer (also commonly referred to as a laptop) and 40 times as much as a tablet.

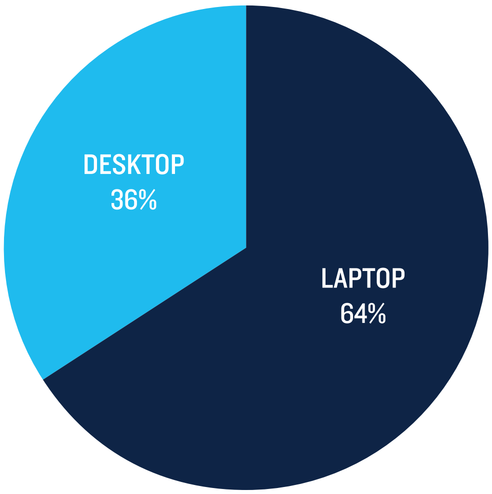
To reduce nationwide computer energy consumption, it is important to make improvements in both desktop and

FIGURE 1: TYPICAL ENERGY USE OF BATTERY-POWERED DEVICES VS. DESKTOP COMPUTERS[8]

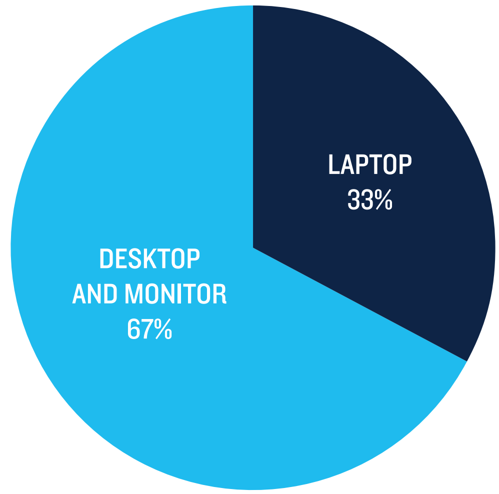


FIGURES 2 AND 3: DESKTOP AND LAPTOP (2014) SALES AND ENERGY USE[9]

SALES



ENERGY USE



laptop computers. Even though desktop computer sales are declining, stories of the demise of the desktop in favor of mobile alternatives are overstated. The reality is that desktops are not going away anytime soon; they remain a staple in office and education buildings and for some specific home uses such as gaming, in part because they allow users to expand their capabilities, such as by adding graphics cards. Desktops are responsible for roughly two-thirds of computer energy use and represent the biggest savings opportunity, as shown in Figures 2 and 3. However, as laptop sales continue to increase and as energy efficiency policies succeed in reducing desktop computer energy use, laptops will be responsible for a greater share of computer energy use, and opportunities to improve their energy efficiency should not be ignored.

If the recommendations in this issue brief were adopted via state and eventually federal minimum efficiency standards, the national savings would be staggering, as illustrated in Table 1.

ENERGY-SAVING OPPORTUNITIES IN COMPUTERS

Whether in homes or in businesses, most computers spend the majority of their time idle or performing low-intensity tasks. Users are either away from their computers, at their desks but doing something else, or even working at their computer performing light tasks such as browsing the Internet, or reading email.[10] The average user spends only a small percentage of time performing high-intensity, more energy-consuming tasks, such as playing computer games or editing video.

The problem is that most of today's computers continue to draw significant amounts of power when idle or doing low-intensity work. Their components—processors, motherboards, disk and DVD/Blu-ray drives, graphics cards, power supplies, fans, and dozens of others—still use a substantial amount of electricity when idling.

TABLE 1: BENEFITS OF REDUCING U.S. COMPUTER AND MONITOR ENERGY USE BY 30 PERCENT

Energy Savings	Electricity Bill Savings for U.S. Consumers and Businesses	Pollution Reduction
29 BILLION KILOWATT-HOURS PER YEAR	**$3 BILLION** PER YEAR	**20 MILLION** METRIC TONS OF CO_2 PER YEAR
Equivalent to the electricity use of all the households in Indiana		*Or the equivalent emissions of* **10** COAL-FIRED POWER PLANTS (500 MEGAWATTS EACH)
		Plus large reductions in other pollutants from coal power plants that cause a range of illnesses from asthma to heart attacks

FIGURE 4: BREAKDOWN OF POWER DRAW IN SAMPLE DESKTOP PC AND MONITOR IN IDLE MODE[11]

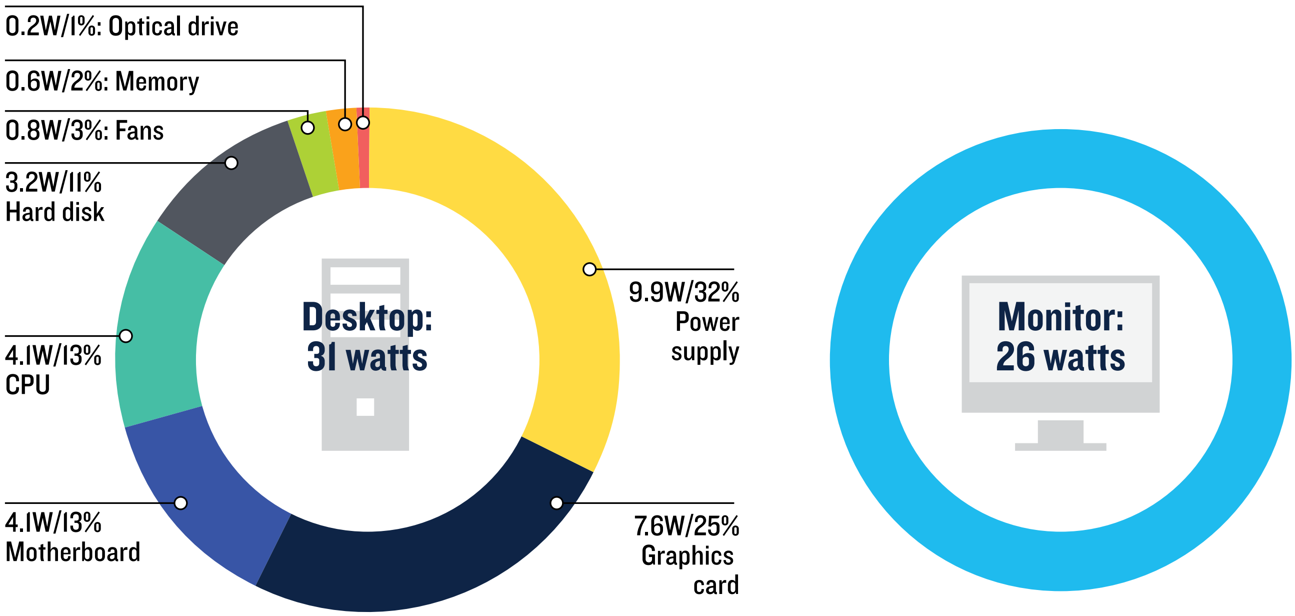


Figure 4 illustrates the power draw of the main components of a typical desktop computer in idle mode.

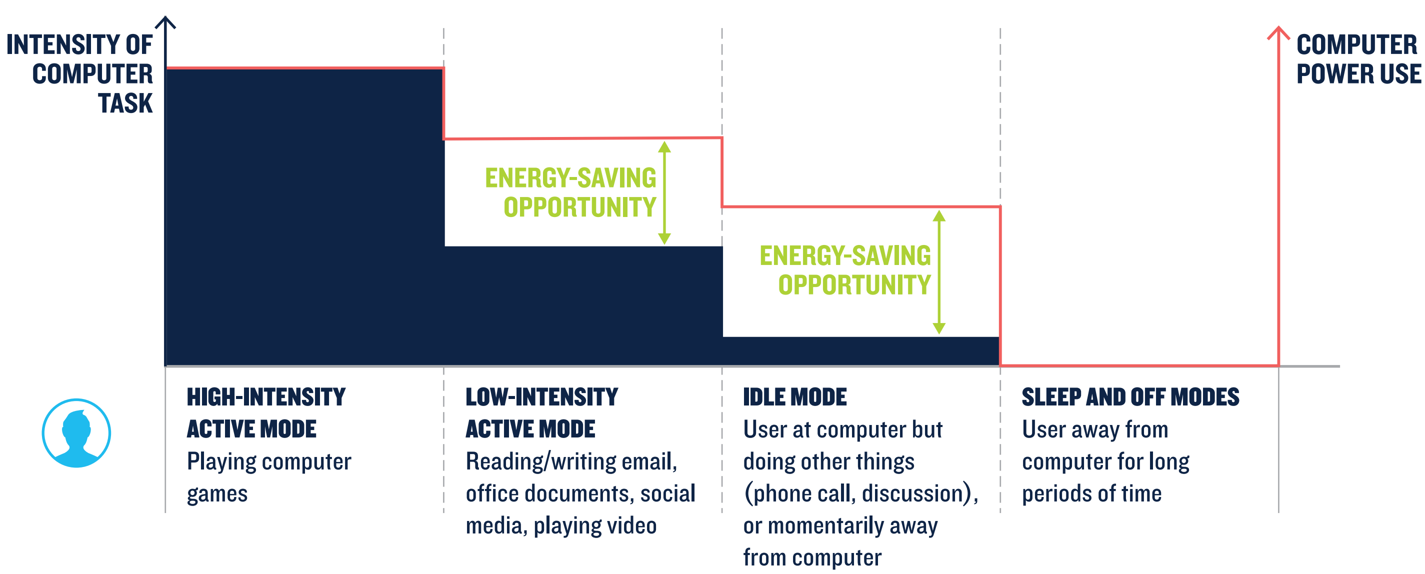
Smartphones and tablets use highly sophisticated and dynamic power management to adjust power demand to meet user and application needs at millisecond and even microsecond timescales, such as between keystrokes when a user is typing. Unfortunately, the majority of today's desktop computers are not configured to take full advantage of these power-saving capabilities. They still rely mostly on minute-scale power management, such as switching off the display after 15 minutes of user inactivity and putting the computer to sleep after 30 minutes.

Manufacturers have strong incentives to reduce maximum power use in peak-performance mode to minimize heat generation, and therefore component size and cost. But they have little incentive to minimize idle and low-intensity active modes' energy use in desktops since heat dissipation is not a problem in idle mode.

Figure 5 illustrates that a standard desktop computer does not reduce power proportionally with the intensity of the computing task at hand. Computers spend from 50 percent to 77 percent of their time in idle and low-intensity active modes and draw much more power than necessary.[12]

Increasing their ability to scale power down when not performing high-intensity tasks, just as notebook computers do to run longer on a battery charge, could dramatically reduce desktop computers' overall energy use.

FIGURE 5: COMPUTERS DO NOT REDUCE POWER PROPORTIONALLY TO THE WORK AT HAND



DEMONSTRATION PROTOTYPE SHOWS POTENTIAL FOR MAJOR DESKTOP ENERGY USE REDUCTIONS

NRDC worked with electronics power-management firm Aggios and the California investor-owned utilities to optimize energy efficiency on a typical desktop computer. We were able to reduce idle power by half compared with an equivalent non-optimized machine. This prototype demonstrates the feasibility of deep reductions in desktop idle power draw, with no noticeable impact on computer response time, and at minimal extra cost.

Both computers used the same latest generation Intel i7-6700k CPU, 16 gigabytes of memory, and a 1-terabyte disk, which places them in a relatively high performance category. For the optimized computer, we chose the MSI B150M ECO motherboard because it provides advanced power-tuning software tools, and we used these capabilities to optimize power management of the motherboard.

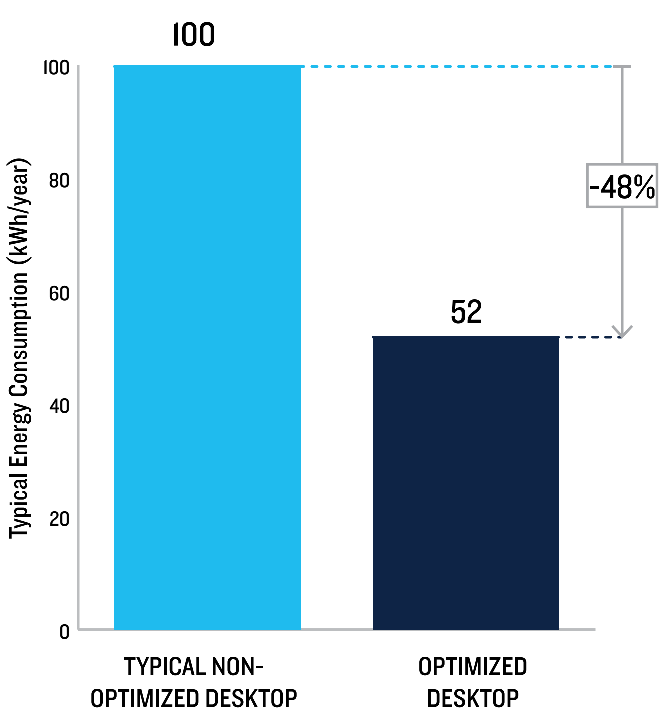
We also selected more energy efficient memory (DDR4) and disk (Western Digital Green drive vs. a Blue drive on the typical PC). We then fine-tuned CPU power management to enable the CPU C8 state, a very low-power state that the CPU can enter when it has no work to do for periods as short as a few milliseconds, such as between keystrokes. This resulted in an internal power draw of 7.7 watts in idle mode, vs. 16.4 watts for the typical computer.

Our next challenge was to find a power supply capable of providing up to 300 watts of power to allow the computer to operate at full throttle when needed, while still being relatively energy efficient when idling at 7.7 watts internal, which represents only 2.5 percent of the power supply's maximum power.

The best 300-watt power supplies we could find were less than 60 percent efficient at that load point. We therefore turned to power supply industry experts Power Integrations, a Silicon Valley company that manufactures integrated circuits for power supplies, and Japan-based ROHM Semiconductor for their Powervation digital power management solutions. They developed a prototype for a 300-watt desktop power supply that is 70 percent efficient at 8 watts, while achieving the 80-PLUS Silver level at higher load. Power Integrations estimates that the extra material cost of this power supply is less than $1 per power supply.

The result: The overall power consumption of the optimized desktop was 11.4 watts, roughly half of the 22.4 watts of today's typical desktop.

FIGURE 6: DEMONSTRATION PROTOTYPE: REDUCTION OF COMPUTER POWER IN IDLE MODE THROUGH COST-EFFECTIVE SOFTWARE OPTIMIZATION AND HARDWARE UPGRADES[17]



WHAT CAN CONSUMERS DO?

While some tech-savvy computer users can optimize their machines by changing software settings and upgrading components, most users don't have that expertise. Therefore, it is critically important that manufacturers optimize their machines at the factory so that they run in the most energy-efficient mode for all, while still providing the experience and performance users expect.

Computer efficiency standards will ensure all consumers benefit from the latest energy efficient technology. But until these standards are adopted and go into effect, here are a few things users can do to minimize the energy waste by their computer:

1. **ENERGY STAR:** Buy an ENERGY STAR computer, as shown on the product label.
2. **Smaller is better:** Buy a laptop or mini-desktop if you don't need a full-size desktop; the smaller devices use a fraction of the energy.
3. **Enable power management:** Ensure your computer is set to automatically power down to sleep or off mode after 30 minutes (or less) of inactivity.
4. **Switch off:** Manually power your machine down to off or sleep mode when you have finished using it, which will save up to 30 minutes' worth of energy use. This adds up to a substantial amount of energy and money saved over one year.

5. **Avoid screen savers:** Disable the screen saver and set the screen to just turn off instead. The days are long past when CRT monitors' screen coatings burned off when static images were displayed for too long. Nowadays, "screen saver" is a misnomer because it increases energy use instead of saving it.
6. **Close unused windows:** Close browser tabs and applications when finished using them. Tabs and applications that are open, even when in the background and unused, continue to use system resources, making the computer work harder and draw more power than necessary.

HOW TO REDUCE DESKTOP COMPUTER ENERGY USE: MANUFACTURER OPTIONS

Here is a breakdown by component of the key design and configuration opportunities for manufacturers to increase computer efficiency:

PROCESSOR

The processor, also known as the central processing unit or CPU, is the "brain" of the computer, providing a large part of the computation capability necessary to run programs and perform the majority of tasks. Tremendous progress has been made in reducing the power draw of modern CPUs when not actively executing instructions. Newer CPUs have a number of deep sleep states, called C-states, that they can enter and exit very rapidly, depending on whether they have a task to perform.

For example, the Intel i7-6700K CPU has a maximum thermal design power of 91 watts (the maximum processor power that the computer is designed to dissipate to avoid overheating). But it can reduce its power to as little as 1.8 watts in its lowest power state and is able to return to its ready state in less than 0.2 milliseconds, which is imperceptible to the user.[13,14]

Unfortunately, many computers have not been designed or configured to take full advantage of their CPU's real-time power management. Some take only partial advantage of this capability, while others fail to transition because of system hardware configuration issues.[15,16]

Efficiency Recommendations: Manufacturers should design, test, and ship all computers with low-power sleep states fully enabled and operational. Additionally, fans should be set to turn off when not needed, such as when the CPU is idling, because the low-power draw also means low heat dissipation.

MOTHERBOARD

The motherboard is a computer's nervous system, connecting the CPU, memory, disk drive, and other critical components. The motherboards in many desktop computers are not designed to minimize energy use when the computer isn't working hard. Components like video and audio ports continue to draw higher levels of power than necessary even when no device is plugged into them.

Efficiency Recommendations: Advanced power optimization features like those of the MSI B150M ECO should be added to the motherboards of all computers shipped in the country. This would cost less than 10 cents per computer and would result in significant energy reductions.[18] (The costs are so low because the motherboard changes require only software, not hardware, and the price of software development and maintenance spread over millions of units adds only a few cents per computer.)

DISK DRIVE

A computer's hard disk drive holds its long-term memory, permanently storing data like installed programs, documents, music, videos, and photos. Unfortunately, traditional hard disk drives (HDDs) often spin and use energy continuously, even when no data access is occurring. While smaller, 2.5-inch drives use less energy than their larger, 3.5-inch counterparts, they are more expensive in computers with high data-storage capacity and offer slightly lower performance. New, solid-state drives (SSDs) use far less energy while providing much higher performance, but they also are more expensive, particularly for large-capacity models.

Efficiency Recommendations: Hybrid disk architectures can provide a cost-effective solution for manufacturers until large-capacity SSD prices come down enough. For example, such a hybrid disk architecture may consist of a small-capacity SSD coupled with a larger secondary HDD.

The small SSD provides high performance at relatively low cost (because SSD cost is proportional to data capacity, small-capacity SSDs are quickly becoming very affordable), while the large HDD can be spun down into a low-power state when the computer is inactive. The SSD provides a fast restart, giving the HDD time to spin back up, with no impact on user experience. In fact, response time is improved, thanks to SSD performance, and energy consumption is significantly lower. Although such a hybrid disk architecture costs a little more upfront, it typically more than pays for itself in reduced energy costs over the life of the computer.

POWER SUPPLY

A computer's power supply unit, or PSU, acts like the computer's digestive system, converting power from the wall outlet (110V AC) to the various voltages needed by the computer's components (12V/5V/3.3V DC).

Unlike laptop adapters, which are external to the computer in the form of a small "brick" on the power cord, most desktop computers use internal power supplies.

Desktop power supplies have traditionally been optimized for active mode rather than for idle mode, despite the fact that computers are idle, or almost idle, most of the time. The voluntary power supply efficiency certification program 80-PLUS, widely used in the computer industry, is focused on active load, which made sense when it was introduced, but it needs to be adjusted now that computers are better able to scale power down in idle mode.

Even with highly efficient desktops that implement the strategies cited previously for the CPU, motherboard, and disk, and that draw very low levels of power internally when idle, overall system efficiency is affected by the power supply. The efficiency of today's typical desktop PSU drops precipitously at very low load levels, even with those PSUs that are 80-PLUS certified, with efficiencies as low as 30 to 40 percent when the computer is in idle mode. In other words, two-thirds of the computer energy use in idle may be wasted in the power supply.[19]

Efficiency Recommendations: One approach to address this issue would be to include a separate low load converter, similar to the standby converter used by many computers in sleep mode. This is essentially a hybrid approach in which the power supply switches between a low load converter and a high load converter, depending on the load level. Most of the activity of typical computers, which includes idle and low-intensity tasks, can be supported by the low load converter, with the high-load converter supporting higher-intensity tasks like gaming. This design costs less than a dollar extra per power supply, and it can pay for itself in just a few months of use.[20]

GRAPHICS

Graphics cards or graphics processing units (GPUs) translate computer data into pixels on the screen, and sometimes on multiple screens, many times per second (typically 30 to 60 frames per second, or even more often). Meanwhile, computer screen resolution continues to increase (from 1 megapixel for high-definition [HD] monitors to 2 megapixels for full HD and more than 8 megapixels for 4K monitors). Graphics cards come in two main types: integrated on the CPU, or discrete in the form of an add-in card plugged into the motherboard. Integrated graphics are typically lower-performance (although they are improving rapidly) and draw lower power; discrete graphics are typically used for gaming or to support high-resolution multi-display configurations and draw higher power. Discrete graphics are used in only about a third of computers sold today, but that is enough to be a significant factor in computer energy use in aggregate.[21] Older discrete graphics cards can draw more power than the rest of the computer in idle mode, when there is no change on the screen. Even in low-intensity active mode, computers can rely on integrated graphics to update the display and keep the discrete graphics switched off most of the time.

Efficiency Recommendations: Fortunately, graphics card manufacturers have been making great progress in reducing the power use of discrete graphics in idle mode. Hybrid graphics configurations switch between integrated and discrete graphics, depending on the task at hand. Even in configurations where the monitor is plugged directly into the discrete graphics port and cannot use hybrid graphics, manufacturers can power down portions of the graphics card that are not necessary to support idle and low-intensity active modes. Discrete graphics can also power down to very low power levels when the display turns off after a period of user inactivity. These strategies should be optimized and configured on all computers by default at the factory so all users can benefit from them.

OTHER STRATEGIES

There are many other ways manufacturers can reduce electricity use in computers and decrease user utility bills without affecting user experience and performance, including:

Power management settings: Settings such as display default brightness, auto dimming, auto power off, and the computer auto-sleep feature can have a large impact on a computer's energy consumption. Manufacturers don't always ship computers with optimized settings, as we found during our testing on two recent all-in-one desktop computers.[22]

Faster wake from sleep: Some computers can wake up from sleep much faster than others. For example, one all-in-one machine we tested woke up in less than 2 seconds, while it took another more than five seconds.[23] Users are less likely to disable sleep mode with computers that wake up almost instantly than with those that take 5 seconds or longer. Thus, minimizing wake-up time is another important strategy to save energy in computers. Another strategy is to improve power management user experience and interface so that fewer users disable sleep mode.

Panel self-refresh: This feature uses dedicated memory in the display to refresh the screen when nothing changes, allowing the GPU to reduce its power demand. Already implemented in the integrated monitors of many laptops, panel self-refresh could have an even larger benefit in desktops and laptops with external monitors.

Software efficiency: Optimizing the operating system, common applications like web browsers and media players, and other programs can save power.[24] For example, tasks can be grouped together ("task coalescing") to increase the amount of time when the system is inactive between tasks, thereby reducing power demand.

Semiconductors: Semiconductors are continuing to improve in performance and efficiency. The size of transistors is shrinking, reducing energy use in chips and memory, and there are new technologies that promise higher performance for less energy (examples include 3D Xpoint memory, memristors, and photonics).

DISPLAY/MONITOR ENERGY-SAVING OPPORTUNITIES

The main display efficiency opportunities available today include the following:

Light source efficiency improvements: LED (light emitting diode) technology is getting more efficient and cheaper every year. Utilizing some of the highest-efficiency LEDs available at time of manufacture saves energy compared with older, less efficient LED technology.

Enhanced light-filtering film: Film enhancements, such as reflective polarization, are a low-cost means to improve light transmission and reduce the amount of light lost as absorbed heat in the display. Many displays do not use enhanced films today.

Power supply improvements: Standalone displays use their own power supply, and this remains a significant source of energy loss. High-efficiency power supplies often provide a cost-effective way to save energy.

Dimming: Efficiency opportunities in this category include automatic brightness control (adjusting a display's brightness to increase in bright ambient conditions and decrease in more dimly lit conditions), other dimming strategies such as "global" or "local" dimming (adjusting LED power to the brightness of the content), and shipping monitors with optimal settings instead of overly bright settings.

Emerging technologies will provide further opportunities for display efficiency in the future. These include organic LED (OLED), which is a new, highly efficient alternative to liquid crystal display (LCD) technology; quantum dots (semiconductor devices that optimize the quality and energy efficiency of color rendition in LCD screens); and improvements in LCD panel transmissivity.

DISPLAY (MONITOR) EFFICIENCY

Computer monitors include both standalone and integrated displays. Standalone displays are used as the primary monitors for desktops, and increasingly often as secondary displays when laptops and desktops are used with multiple screens. Integrated displays are built into notebooks and all-in-one desktop computers. Both types of displays use the same underlying technology and present similar efficiency opportunities. Our testing on the all-in-one desktop computers found that the display of one computer used 58 percent less power than the display of another computer of the same screen size and resolution.[25] NRDC estimates that it is possible to cost-effectively reduce average monitor energy consumption by 30 to 50 percent using existing technology, with further improvements probable in the future using emerging technologies.

ENERGY-SAVING OPPORTUNITIES FOR LAPTOPS

While laptops typically use less energy than desktops per unit, they still consume much more than necessary when plugged in. There also are dramatic differences in the power draw between "desktop replacement" laptops, such as gaming laptops and portable workstations that are intended for primary use plugged in and are designed for only limited portability, and the ultra-portable models that are designed for primary use on battery power and can last all day on a single battery charge.

Laptops also represent the bulk of today's computer market in the United States, with roughly two-thirds of sales, and are expected to be responsible for the majority of computer energy use in upcoming years.[26] Reducing energy waste in laptops is therefore important to achieve the full energy savings potential in computers.

Laptops already use many of the previously described energy-saving strategies due to the market incentive for manufacturers to design them to run as long as possible on a battery charge. However, not all efficiency strategies affect battery life, so not all have been applied to laptops. For example, low-load power supply efficiency is not always optimized as much as it could be but it is still important for laptops because they are operated mostly while plugged in (unlike phones and tablets, which are operated mostly on battery power). As noted earlier, laptops use external power supplies, the black bricks on the power cord. Existing policies, such as federal energy efficiency standards for external power supplies, have focused on active-mode efficiency. This is useful for generic external power supplies but is not as effective for laptop computers, which spend most of their time either idle, performing low-intensity tasks, or in sleep or off mode.

Moreover, while laptops tend to be designed to optimize energy use when operating on battery power, some of the energy-saving strategies are deactivated when the laptop is plugged in. For example, CPU and motherboard power management may not be enabled to the same extent when plugged into an outlet. Ensuring that laptops are configured to optimize power use whether operating plugged in or on a battery would yield substantial energy savings.

Other strategies that can help reduce laptop energy use include panel self-refresh, which is not yet implemented on all laptops; and improvements in software, semiconductor, and display efficiency. While savings will vary by computer, together these strategies could significantly reduce laptop energy use over the next few years if implemented across all laptops.

WHY STANDARDS ARE NECESSARY

Efficiency standards are necessary to avoid the situation where, in order to compete on price, manufacturers sell computers and monitors with cheap and inefficient components. Consumers do not have the information on efficiency and potential savings to be able to differentiate between energy-guzzling computers and more efficient ones. Therefore, the market is driven primarily by price and features, and fails to account for efficiency and energy costs, particularly for products and operating modes that are not related to battery life.

TABLE 2: SUMMARY OF PRIMARY EFFICIENCY OPTIONS FOR COMPUTER MANUFACTURERS		
Opportunity	**Desktops**	**Notebooks/Laptops**
Power management	Ship computer with optimized power management settings and user interface. Design computer to wake from sleep as quickly as possible	Optimize not just when on battery power, but also when plugged in
Processor	Fully utilize low-power modes called C-states	Optimize when plugged in
Motherboard	Power off ports and fans when not needed	Optimize when plugged in
Disk drive	Use partial or full solid-state architecture, with secondary disk not spinning when computer is idle	Same as desktops
Power supply	Achieve high efficiency at idle and light load	Similar to desktops, but in the external power supplies used by laptops
Graphics	Use low power in idle, when there are few or no graphics to process	Optimize when plugged in
Panel self-refresh	Refresh screen from memory rather than from GPU when there are no changes	Implemented in some but not all laptops. Extend to all laptops
Software efficiency	Optimize operating system and applications to reduce energy waste	Same as desktops
Semiconductor efficiency	Take advantage of latest efficiency improvements in computer chips	Same as desktops
Display efficiency	Take advantage of latest efficiency improvements in backlighting, light filtering and electronics	Same as desktops

Voluntary energy efficiency labeling programs like ENERGY STAR encourage innovation and leadership by highlighting the most efficient products, but they do not affect the most inefficient part of the market.

Energy efficiency standards are necessary to overcome this market failure. They motivate manufacturers to compete on how they can achieve energy savings most cost-effectively, instead of how they can save pennies on manufacturing costs while saddling consumers with extra operating expenses.

There are many other advantages of standards, including:

- Standards set common goals across the industry. Manufacturers might be reluctant to pursue efficiency strategies alone; they are more likely to do so if standards ensure that the entire industry will do the same.
- Standards also optimize coordination across an industry whose products are made with many components, necessitating that hardware and software manufacturers design fully integrated solutions.

Efficiency standards are set to be cost-effective, meaning that they save money for consumers overall: Efficiency standards are designed so that on average, any upfront cost for a more efficient product is lower than the savings on the owner's electricity bills over the life of the computer.

Low-income consumers benefit the most: Budget computers are typically the least efficient, often using outdated components. While they are a little cheaper at purchase, the upfront savings are rapidly offset by the extra cost of the energy guzzled by these machines over their lifetime. By reducing the total cost of ownership of computers, standards put money back in everyone's pockets, particularly low-income households.

Standards have no impact on performance: Current computer energy efficiency standards are focused on modes when the computer is not actively used (idle, sleep and off), and many components can be put in a very low power state. The standards do not affect active performance and functions.

Efficiency standards will accelerate innovation: The computer standards considered by the California Energy Commission and the United States, and those already in place in the European Union and other countries, are performance-based, meaning that they leave manufacturers the flexibility to achieve them at the lowest cost possible. And because they only cover idle, sleep, and off modes, there is no constraint on new functions in active mode.

GOING FORWARD

Computers and monitors represent one of the largest energy uses currently without efficiency standards in the United States. It is time to change that by implementing commonsense, cost-effective energy efficiency standards for computers and monitors. If standards were adopted nationwide at levels equivalent to those proposed in March 2016 by the California Energy Commission, they would save America's consumers $3 billion on their electricity bills annually while reducing unnecessary power plant pollution by 20 million metric tons of carbon dioxide per year.

About the author

Pierre Delforge joined NRDC in 2010 after 20 years in the IT industry. At NRDC, Pierre has been actively involved in multiple computer efficiency proceedings, including the development of ENERGY STAR version 6 for computers, the European Union's Ecodesign regulation for computers, and the California Energy Commission's and U.S. Department of Energy's ongoing rulemakings. https://www.nrdc.org/experts/pierre-delforge.

While this report was developed on the basis of projects performed in collaboration with Aggios and the California investor-owned utilities and their consultants, Energy Solutions and Xergy Consulting, the content of the report represents solely the views of NRDC. This issue brief was reviewed by Nate Dewart and Bijit Kundu (Energy Solutions), Davorin Mista (Aggios), Pete May-Ostendorp (Xergy), and Kala Viswanathan and Lauren Urbanek (NRDC).

ENDNOTES

1 Navigant Consulting, Inc., and SAIC, "Analysis and Representation of Miscellaneous Electric Loads in NEMS," prepared for the U.S. Energy Information Administration (EIA), May 2013, www.eia.gov/analysis/studies/demand/miscelectric/.

2 2014 shipments times 5 year life for desktops, 4 years for notebooks, Gartner Newsroom press release "Gartner Says Worldwide PC Shipments Grew 1 percent in Fourth Quarter of 2014", January 2015, www.gartner.com/newsroom/id/2960125.

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4 Aggios, Inc., is a California corporation devoted to delivering innovative products and services to improve the energy efficiency of mobile, plug-load, and Internet of things (IoT) electronic devices. Aggios is engaged in product development, technical standard definition, and codes and standards activities. For more information, see www.aggios.com.

5 The California investor-owned utilities, including Pacific Gas and Electric, Southern California Edison, and Sempra, invest in energy efficiency research and development as part of their customer-funded codes and standards energy efficiency programs.

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