

28 *Green IT*



You might think that a book about system administration would be the last place to find a chapter on environmental and social consciousness. But now that large IT installations have become commonplace, the environmental impact and resource consumption of the equipment we oversee have started to attract attention. Green IT is the art and science of reducing these hidden and not-so-hidden costs.

Although each of us can make a difference through small changes in our choices and behavior, most improvement comes from centrally driven efforts to effect change. For example, no amount of “Choose unleaded gasoline! It’s a whole lot better!” would have equalled the impact of the federal mandate to stop producing cars that required lead. Guess who can set similar mandates for your IT organization? You can!

But why bother? Bragging rights and the satisfaction of doing the right thing for the planet may be reason enough for some. But there are practical reasons to convince decision-makers in your organization to consider a green IT effort as well:

- **Lower initial costs** – by minimizing the equipment that your organization buys and uses, you reduce capital expenditures. By minimizing the size of the data center required, you can reduce real estate costs.

- **Lower operating costs** – power, management, and maintenance for equipment cost money over time. Efficient use of fewer pieces of equipment means that your organization spends less on the direct costs of operations.
- **Indirect cost savings** – you pay for electricity twice: once to power your equipment, and then again to cool down the equipment after it has converted that expensive power into heat.¹ Less equipment means less cooling, less square footage for IT projects, and fewer people dedicated to IT operations. Fewer people means less spent on rent, office cooling, wages, benefits, and support.

This chapter focuses on some basic concepts you can use to reduce your IT organization's energy and resource consumption. We've targeted organizations that have from 1 to 500 servers in their data centers. If your environment is larger, you should consider hiring an expert in green data-center construction to achieve the most dramatic results.

28.1 GREEN IT INITIATION

What exactly does it mean to be “green”? We define it as

- Lower power consumption
- Smaller physical plant requirements
- Lower consumption of consumables
- Recyclable outputs

There is no silver bullet or single path to a green IT environment. Despite some vendors' claims, you cannot purchase one product that makes all the greenness in the world shower down upon you. Specifically, green IT is a lot more than just server virtualization. And, like so many aspects of system administration, green IT is more a journey than a destination. You must first visualize where you want to go, map out a plan to get there, and chart your progress along the way. Ongoing measurement and monitoring must be key elements of your overall plan.

Start your green IT journey by assessing the eco-friendliness of your current environment. Take a comprehensive view of all IT within your organization, not only to maximize the project's impact but also to ensure that you don't ultimately end up playing the “squeeze the balloon” game. For example, it might seem eco-wonderful to remove *all* the servers from your environment until you discover that eliminating your 50 managed servers has resulted in users purchasing and deploying 600 rogue server-class systems in their cubicles as part of a “personal server deprivation revolt.”

1. The informational work done by IT equipment is not significant in a thermodynamic sense. Computers are essentially 100% efficient at converting electricity into heat.

Here is some information to gather as you start your green IT assessment:

- **Equipment survey** – everything, including servers, laptops, workstations, monitors, printers, storage devices, network gear, backup devices, UPSs, and cooling units. Capture the location, model number, “size” (in units appropriate to the specific equipment), and age of each item.

It’s helpful to have power consumption data for each item as well. Rated power consumption can be misleading—better to measure a device’s actual energy use with a Kill A Watt meter, which costs around \$20.² For devices that have both active and sleep states (e.g., printers), you may want to record average energy use over a one-day or one-week period.

- **Accounting of consumables** – paper, toner, storage media
- **Organizational metrics** – including gross revenue, number of employees, number of physical locations, total facility energy consumption, IT equipment energy consumption (in data centers), data center cooling energy consumption, total IT capital cost, total IT operations cost, and total facilities costs for data centers.

Once you’ve collected this baseline data, identify one to three targets for optimization. These targets should be tied to your organization’s overall strategy for success and growth, and if achieved, they should also demonstrate progress toward becoming a greener IT shop. We can’t tell you what targets will work best for your environment, but here are some appropriate examples:

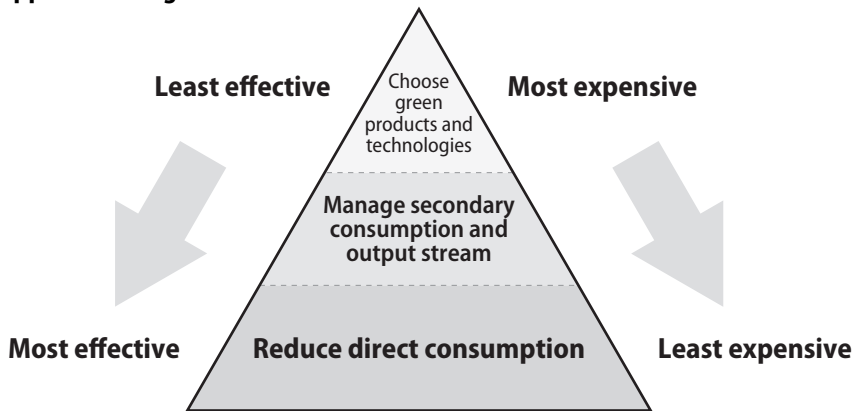
- Data center energy consumption per dollar of gross revenue
- Number of employees per physical server
- Sheets of paper used per employee per month
- Average energy consumption of an employee’s workspace equipment
- Average life of a laptop computer
- Data center energy use as a proportion of total facility use³

Plan to reassess your green IT status at least yearly, but review energy consumption monthly.

28.2 THE GREEN IT ECO-PYRAMID

It’s easy to see how eco-unfriendly your organization is. The hard part is making (and monitoring) progress toward the goal of being green. To help you navigate the sea of choices presented in this chapter, we map green IT strategies into three divisions, as shown in Exhibit A on the next page.

2. This product is designed for the North American market, but similar products exist for other markets. A version made for the UK can be found at reuk.co.uk/Buy-UK-Power-Meter.htm.
3. This metric multiplied by 100 yields the percentage of facility power delivered to IT equipment and is known in the industry as “DCiE.” It is a standard metric that can be used to compare organizations. Power usage effectiveness (PUE) is the reciprocal of DCiE and is a common benchmark for very large data centers.

Exhibit A Approaches to green IT

We show these categories in the form of a pyramid because the strategies at the bottom have the most significant impact and are most likely to provide secondary benefits. As you go up the pyramid, the strategies involve more cost and effort and tend to be less effective.

Reducing direct consumption should always be your first-choice strategy; less is more. If you can achieve your mission with less effort and fewer resources, that eliminates both capital and operational costs.

Mitigation of secondary consumption is the next best strategy. For example, the cooling needed to support a server counts as secondary consumption since it only occurs because the server exists in the first place. Optimizing the HVAC system to minimize cooling expenses saves money, but it doesn't save as much as eliminating the server entirely.

Perhaps somewhat nonintuitively, choosing products and technologies that have been designed to be “green” is our lowest-value strategy. Think of it this way: we first reduce the number of cars on the road as much as possible, and only then do we replace the remaining cars with fuel efficient models.

28.3 GREEN IT STRATEGIES: DATA CENTER

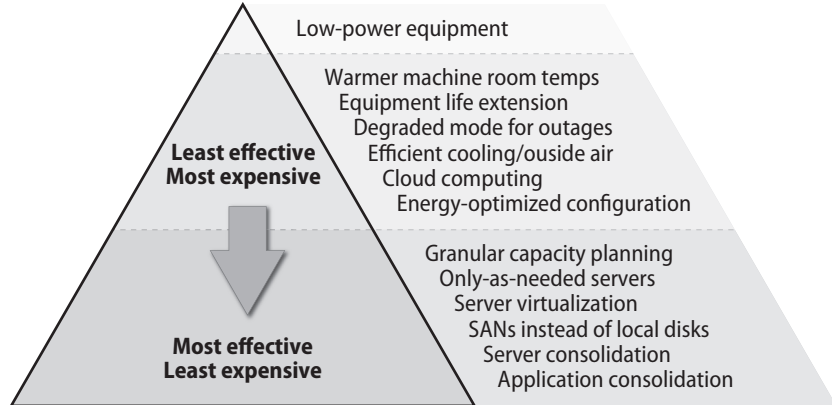
Data centers are excellent targets for green IT initiatives because they typically operate $7 \times 24 \times 365$ and are under the direct control of the IT group. A study by Lawrence Berkeley Laboratories showed that data centers can be as many as 40 times more energy-intensive than conventional office space.⁴

At this level of consumption, special strategies are required. As shown in Exhibit B, the strategies to reduce direct consumption at the bottom of the pyramid are

4. See eetd.lbl.gov/emills/PUBS/PDF/ACEEE-datacenters.pdf for lots of gory details.

the most effective approaches. You don't need to use every strategy in a given environment, but every little bit counts.

Exhibit B Green IT strategies for data centers



Application consolidation

Over time, organizations and IT departments tend to accumulate applications. New applications come onboard to support specific business initiatives and the CEO's pet projects, but old applications rarely die. More commonly, they linger "on the road to retirement" for a decade with no one being willing to take the risk of pulling the plug. Whatever the reason, the number one opportunity for progress in an established organization is to consolidate applications to the minimum set that meets current business needs.

Let's consider an example organization that has three applications: EmployeeLinq, AccountAwesome, and ElectricClockster. Although this is a simplified example, it's loosely based on real-world applications used by one organization that we examined. Each of the applications had a back-end database server, an application server, and a web front-end server. That's a total of nine servers to support these three applications.

The first step toward consolidation is to map out the functions provided by each application. Table 28.1 on the next page shows the features of our example apps. As you can see, there's quite a bit of overlap.

This organization had three systems that could be (and were!) used to track time, two systems that could do payroll (though only one was currently in use), and many other overlapping functions.

This situation came to pass because three different departments—Finance, Human Resources, and Operations—had each chosen their own application. Not only does this lack of coordination waste energy and computing resources, but it

Table 28.1 Functional breakdown of three applications

Function	EL	AA	EC
Accounts payable/receivable		X	
Benefits management	X	X	
Employee time tracking	X	X	X
General ledger		X	
Payroll	X	X	
Time reporting	X	X	X
Vacation/sick day tracking		X	X

also complicates or forestalls integration of data among departments. In this case, moving the organization to a single application trimmed software, hardware, and energy costs by over 60% and resulted in smoother data flow within the company.

Your situation is probably not this dramatic, but if you take the time to map out your application domains, chances are that you'll find some significant overlap. The business case for consolidating applications is easy to make because the projected results can (at least in part) be expressed in dollars saved. Data integration and operational improvements are just icing on the cake.

Server consolidation

Most organizations have at least a few “single purpose” servers that operate at 10% utilization or less. For example, we've seen many organizations that have dedicated NTP (network time protocol) servers. NTP is a low-overhead protocol that requires very little computational effort. Reserving a server for NTP is like flying a Boeing 767 cross-country with only one passenger.

Server consolidation is a close cousin of application consolidation and is equally effective. Instead of bundling multiple functions into one application, you bundle multiple services onto one server machine.

Unlike Windows, UNIX and Linux excel at preemptive multitasking. A good solution in the NTP case is to run the NTP daemon on the same servers that provide common infrastructural services such as DNS and Kerberos.⁵

Another common opportunity for server consolidation is presented by database servers that are dedicated to a single application. If you have competent sysadmins and DBAs (and good monitoring), a single database server should be able to host the databases for many applications. Once again, this consolidation reduces license fees, capital costs, and energy consumption.

5. NTP is a special case in that its response latency must be kept low. However, that doesn't mean you can't run other services on the same machine. NTP server daemons are commonly **niced** to give them ready access to the CPU whenever they want it (see page 129). You can achieve similar ends—perhaps even a bit more reliably—through server virtualization.

In some cases, you may be able to reduce the number of servers you need by replacing old, less powerful servers with a smaller number of new, more powerful, and more energy-efficient servers.

SAN storage

One common indicator of IT gluttony is a fleet of servers that are loaded up with hard disks. For example, imagine a data center that has 100 servers, each with six 1TB disks. That's 600 disks that must be manufactured, maintained, powered, and eventually scrubbed and disposed of. The likelihood that these drives' average utilization exceeds 50% is virtually nil.

This approach results in excessive waste because it chops the storage into discrete chunks that cannot be efficiently managed to make "just the right amount" of storage available to each server or application. Some servers may have less than 1TB of actual data in play while others are underprovisioned at 6TB and unable to benefit from the idle drives in their neighbor's chassis. The reality is that it's hard to push much above 30% storage utilization in a typical data center that has discrete storage for each server.

A good alternative to this approach is a storage area network or SAN; see page 274 for more details. SAN technology provides highly reliable storage that is also eco-friendly because sysadmins can allocate the centralized storage space efficiently. Many organizations exceed 90% utilization on their SANs. That's triple the efficiency of discrete storage. Now that SANs can run on Ethernet, there is no longer any major hardware hurdle to deploying this wonderful tool.

Server virtualization

Server virtualization seems to be everyone's favorite topic in the green IT arena, although some of the current buzz is probably fueled by the marketing dollars of the companies selling virtualization platforms.

Server virtualization (covered in detail in Chapter 24) is in fact a fantastic tool. Its eco-impact is similar to that of server consolidation. In both approaches, several applications or services end up running on a single computer. Virtualization reduces energy consumption by reducing the number of chassis in production and achieving higher utilization of the remaining units.

Virtualization offers some additional features that are not provided by consolidation, such as the ability to easily scale out identical systems, the ability to reserve a portion of the hardware's capacity for a given server, and the ability to migrate virtual servers among physical chassis. Those aspects of virtualization are a win.

Virtualization also has a dark side. Applications that are I/O intensive typically do not virtualize well and tend to be more sluggish in a virtualized environment. The virtualization process itself consumes resources, so virtualized systems have overhead that physical systems do not. The additional layers of abstraction introduced by virtualization require constant vigilance on the part of system administrators,

both because the virtualization itself must be actively managed and because virtualization may affect the operation of the hosted systems.

Virtualization is best employed in environments that have adequate IT staff and mature processes. At this point, we don't really recommend server virtualization for beginning sysadmins. However, the technology is rapidly becoming more reliable and easier to use. Soon, it will be inescapable.

Only-as-needed servers

Only-as-needed servers are powered down when not in use. This approach works best in cases where the demand for computing power is predictably cyclical; for example, when the server is linked to the accounting cycle or to work that is only done in the wee hours of the morning. This isn't a common technique, but every once in a while there's a green IT savings opportunity so special that only this trick fits.

You can roll your own implementation with some scripts and Ethernet-connected (managed) power strips. Platforms such as RightScale (rightscale.com) extend the concept into demand-based territory. Using systems such as this, you can set thresholds at which additional servers are automatically spun up (or spun down) according to metrics such as CPU load or transaction volume.

Granular utilization and capacity planning

In green IT, as in other areas, you can only manage what you can measure. Careful data collection is an essential tool for optimizing your environment.

If you track your site's use of resources such as CPU and memory (see Chapter 29, *Performance Analysis*), you can plan your hardware deployments so that you don't have to buy overprovisioned servers "just to make sure" your capacity is sufficient. Monitoring and analysis take time, but they're an excellent basis for "lean and mean" data center management.

Buy only what you need; use only what you must.

Energy-optimized server configuration

Some systems give you the opportunity to save energy by altering the behavior of the system itself.

Power-saving options for Linux



CPUs and CPU cores can be idled to reduce their power consumption. To achieve the lowest possible power consumption, you pack as many threads as possible onto one core or CPU and do not activate additional cores or CPUs until they are needed. Conversely, to achieve the best possible performance, you distribute threads as widely as possible among cores and CPUs to minimize the time-costs of context switching and cache contention. In theory, you must trade away some performance to reduce power consumption.

In practice, the opportunity to idle parts of the CPU only arises when the system isn't busy. In those circumstances, the additional overhead of packing threads onto one core may have no detectable effect. Experiment to see if you can discern any difference with your specific workload.

The process scheduler's power management system consults two control variables, both of which are set through files in the `/sys/devices/system/cpu` directory. The `sched_mc_power_savings` variable controls whether all cores on a CPU are used before activating another CPU, and the `sched_smt_power_savings` variable controls whether all thread slots on a core are used before activating another core. In both cases, a value of 0 turns power saving off and a 1 turns it on.

For example, to turn on both power-saving modes, you could use the commands

```
$ sudo sh -c 'echo 1 > /sys/devices/system/cpu/sched_mc_power_savings'  
$ sudo sh -c 'echo 1 > /sys/devices/system/cpu/sched_smt_power_savings'
```

To make these changes persistent across reboots, check out the `sysctl` command or add the lines to a startup script such as `/etc/init.d/local` on Ubuntu or SUSE (create it if necessary) or `/etc/rc.local` on Red Hat.

A computer's CPU is one of its most profligate consumers of energy (just look at those heat sinks!), so aggressive power management can significantly reduce the system's power use.

Filesystem power savings

You can save power and increase performance by preventing filesystems from maintaining a "last access" time (`st_atime`) for every file. This information isn't very useful, and it theoretically adds a tax of one seek and one write to every file operation. (The real-world impact is harder to quantify because of block caching.)

Zedlewski et al. analyzed hard disk power consumption in a 2003 paper and concluded that seeks cost about 4 millijoules each on an IBM Microdrive; the cost is probably at least double that for a standard drive with its larger armature. Combining the cost of seeks with the cost of writes, we calculate the benefit of disabling last access times to be up to several kWh per drive per year. Not a huge savings, but probably worthwhile for the performance benefits alone; the energy savings are just gravy.

On most filesystems, you can turn off maintenance of the last access time with the `noatime` option to `mount`:

```
$ sudo mount -o remount,noatime /
```

Some Linux systems also support the `relatime` mount option, which provides hybrid functionality. Under this option, last access time is only updated if the previous value is earlier than the file's modification time. This mode allows tools such as mail readers to correctly identify cases in which an interesting file has been changed but not yet read.

See page 987 for more information about cloud computing.

Cloud computing

Take a deep breath, and think outside the box—outside the box of your data center, that is. The recent availability of “cloud computing” has brought many benefits, but one worth mentioning here is energy efficiency. In their quest to provide low-cost, high-reliability services, providers like Amazon have constructed ultra-high-efficiency data centers and utilization management processes. These cloud providers can supply compute cycles that are more eco-friendly than you could ever achieve in your own data center.

If you have applications (especially web applications) that don’t absolutely have to live under your own roof, consider outsourcing their infrastructure to a cloud data center. You still have complete administrative control of the virtual systems that run in this environment. You just never get to physically “hug” them.

Free cooling

Nothing is more disturbing on a cold winter’s day than to walk outside a data center and see the compressor pad whirling away at full speed. It’s 10 degrees outside, but the HVAC engineer apparently designed a system that uses mechanical cooling (and an amazing amount of energy) to pull heat out of the data center regardless of the ambient temperature.

Fortunately, some modern HVAC engineers specialize in data centers and have a better solution to this problem: use outside air for cooling when the temperature is low enough.

Of course, this solution isn’t available everywhere or in every season. The Green Grid, a consortium of technology companies dedicated to advancing energy efficiency in data centers, now produces “free cooling” maps for North America and Europe that illustrate how many hours a year a center can be cooled by outside air in a given area. A more detailed on-line cooling calculator is also available—check it out at thegreengrid.org.

Efficient data center cooling

Various tricks of data center design can be used to reduce the amount of energy used for cooling. For example, the hot aisle/cold aisle layout described on page 1089 concentrates cooling where it is most needed and allows other parts of the data center to operate at higher temperatures.

See Chapter 27, *Data Center Basics*, for a broader discussion of some of these tips.

Degraded mode for outages

Many organizations are obsessed with availability (aka uptime). What often aren’t considered are the additional energy and resources used to ensure a particular level of availability.

Internal customers are accustomed to thinking of services as being either up or down. Consider offering *degraded* service as an additional choice for fault management, and ask whether that might meet the customers' availability needs.

For example, instead of running a fully redundant set of equipment for every production environment, you could use server virtualization to deploy several applications to a single chassis in the event of an outage. This configuration might supply all the standard functionality, but at slower speed than normal. In some cases, this tradeoff can reduce the organization's capital costs by 50% or more.

Equipment life extension

Electronics manufacturing consumes energy and generates toxic waste, so purchases of new equipment entail an environmental cost that isn't necessarily reflected in the price tag. Unfortunately, the technology industry has become so accustomed to rapid innovation and product development that manufacturers often discontinue support for equipment after just a few years.

If your current equipment meets your business needs and is reasonably energy efficient, you may want to consider a life extension strategy.⁶ Such a scheme typically involves scouring eBay and other sources of salvage equipment for similar systems you can acquire cheaply and bring to your site as a source of vintage spare parts. This approach typically extends system life by two to three years, though in at least one case we have kept a system running eight extra years this way.

If older equipment is not meeting performance requirements or cannot be supplemented by on-site spares, another option is to buy new equipment for the production environment and reassign the current equipment to a development environment, where performance and reliability are not as important. This approach doesn't avoid new purchases entirely, but it may delay purchases for the development environment for a year or two.

If equipment simply must be retired, make sure that you turn it over to a legitimate computer recycler who will break it down into component pieces and recycle each piece appropriately. Make sure the recycler has a certified data destruction program so that your data doesn't later show up in someone else's hands.

Computers contain a surprising amount of toxic waste. Whatever you do, don't just throw old equipment into the dumpster—that waste typically goes to a landfill not designed to handle electronics.

Some regions have organizations that provide computer recycling services for free. In the Portland, Oregon, area, freegeek.org is a model recycling program.

6. If your current equipment is not energy efficient, you may be better off replacing it immediately to achieve operational energy savings, even when disposal and replacement costs are considered.

Warmer temperature in the data center

Approximately one-third of the energy consumed in a traditional data center goes to support cooling. Historically, data centers have maintained temperatures in the range of 68–77 degrees Fahrenheit. These values are now seen as conservative.

In early 2009, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) issued guidance that an expanded range of 64.4–80.6 degrees Fahrenheit is acceptable for data centers. Raising the data center temperature by three degrees typically saves an estimated 12% in cooling costs.

See Chapter 27, *Data Center Basics*, for additional cooling tips.

Low-power equipment

When procuring new equipment, take the time to select products that have minimal environmental impact.

The IEEE has standardized the criteria for environmental assessment of electronics in IEEE publication 1680. One evaluation system based on IEEE P1680, the Electronic Products Environmental Assessment Tool (EPEAT), considers a wide range of potential impacts that might be involved in a product's manufacture. It can help you compare products uniformly. The system currently covers desktop and laptop computers, thin clients, workstations, and computer monitors. It is required for U.S. federal government purchases. Visit EPEAT at epeat.net.

Note that EPEAT compliance requires conformance to Energy Star standards (in version 5.0 as of July 1, 2009) for energy consumption during use.

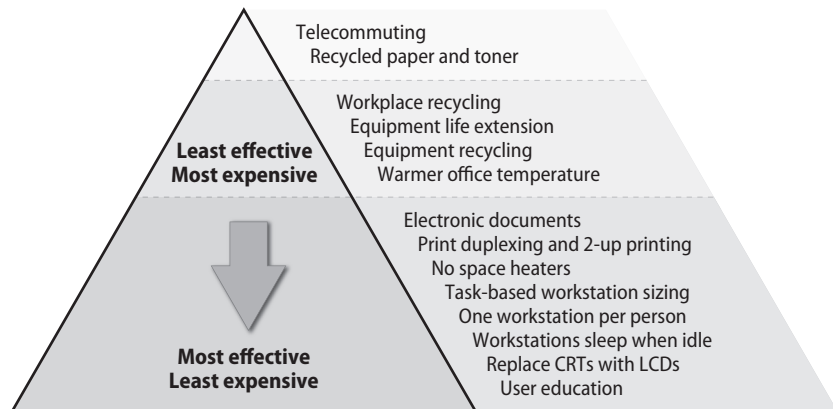
Some server manufacturers (including Dell, Sun, IBM, and HP) offer environmentally focused product families. But even eco-friendly servers have an environmental impact and consume power. The existence of these product lines should not be viewed as a license to add equipment in the name of being green. Focus *first* on reducing the number of servers that you need, *then* pick the most eco-friendly option for meeting that need.

28.4 GREEN IT STRATEGIES: USER WORKSPACE

Staff work areas present another set of opportunities to green up your operations. Exhibit C summarizes some improvements to consider.

Below are listed workspace arenas in which green IT can be a player. Most of the accompanying suggestions are straightforward, and you'll find many of them familiar from other sources. (Chances are that you're already doing some of them.)

- **User education** – encourage users to power off equipment that's not needed, to think before they print documents, and to let desktop equipment go into a power-saving mode instead of running a screen saver (or, better yet, turn it off).

Exhibit C Green IT strategies for the workspace

- **Monitors** – replace CRTs with LCD monitors. They use significantly less power and contain fewer toxic elements.
- **Workstation idle** – centrally configure workstations to “sleep” or power-off when idle for a given period (e.g., 30 minutes).
- **Workstation count** – limit desktop workstations to one per user. Users who claim to need more than one workstation should be encouraged to use a desktop virtualization client.
- **Task-based sizing** – don’t buy “one size fits all” workstations. Have three or four tiers of workstation specifications so that users have the appropriate configuration for their task mix.
- **Personal heaters** – this is not really an IT topic per se, but it’s a pet peeve of ours, and the IT department is usually the one to notice. Do not allow the use of personal space heaters in users’ offices or cubicles. Explain to users that such heaters feed a vicious cycle in which the office HVAC and the heater fight in an effort to enforce different temperature targets. If the user’s work area is truly the wrong temperature, escalate the issue with the appropriate HVAC support team. (Maybe you can offer them some VIP IT support in exchange for their assistance.)
- **Print duplexing** – configure printers to default to double-sided, two-up printing. This works fine for most routine printing, and users can always select something other than the default for special cases.
- **eDocument campaign** – launch a campaign or contest within your organization to find ways to eliminate the use of printed documents.
- **Office temperature** – since office computing equipment is designed to work at much higher temperatures than humans are, raise that office cooling setting to 78°F or higher.

- **Equipment recycling** – once or twice a year, hold equipment recycling days during which staff can pile up their unwanted, unused, or underutilized equipment for your favorite recycling company to haul off. If you're really eco-friendly, let staff add equipment from home to the pile.
- **Equipment life extension** – once a workstation has become too old or too slow to be used by staff with the most intense computing demands, cycle it down to staff who have lower requirements. They'll see it as an upgrade, and you'll squeeze another year or two of life out of it.
- **Workplace recycling** – start a workplace recycling program for used paper. Many recycling companies also accept office plastics (soda bottles, etc.) in the same stream.
- **Recycled paper and printer cartridges** – become a consumer of recycled goods. Purchase 100% recycled paper for your printers and copiers, and buy recycled toner cartridges as well. We've had outstanding luck with Boise Aspen 100 as general-purpose recycled printer paper that's inexpensive and has outstanding ecological characteristics.
- **Telecommuting** – encourage staff to telecommute one or more days per week by installing and supporting technologies that facilitate remote access, such as VPNs, VOIP service at home, and web-available applications. In addition to the benefits for the staff involved, telecommuting reduces the use of transportation and office support services. Make sure, though, that telecommuters turn off their equipment at whichever site they're not occupying on a given day. Otherwise, this policy can backfire, at least from an energy conservation perspective.

28.5 GREEN IT FRIENDS

If you're looking to do even more in the green IT space, you can find both camaraderie and guidance from a variety of organizations and resources. Table 28.2 lists some of the groups that we're familiar with and recommend.

Table 28.2 The green mafia

Organization	Web site	Description
Energy Star	energystar.gov	Consumer product standards
EPEAT	epeat.net	Green electronics manufacturing
French Green IT	greenit.fr	French Green IT blog
Green IT Observatory	greenit.bf.rmit.edu.au	Australian green IT research
Green IT Promo Council	greenit-pc.jp	Green IT for Japan and Asia
Green Standards Trust	greenstandards.org	Office equipment recycling
IT Industry Council	itic.org	General best practices for IT
Less Watts	lesswatts.org	Saving power with Linux
The Green Grid	thegreengrid.org	Data center focus

In addition to stockpiling green ideas, many of these organizations have their own sets of benchmark data that you can use to find out how your organization compares with others of similar size and activity.

28.6 EXERCISES

- E28.1 Use a Kill A Watt meter to measure the power consumption of your desktop workstation under various load conditions, including sleep mode or power-save mode. How much power would be saved if you turned your workstation off every night?
- E28.2 Write a script that emails the system administrator when CPU load indicates that a new server should be spun up.
- E28.3 Make a list of the main applications that your organization uses today. Which ones have overlapping functionality?
- E28.4 Visit thegreengrid.org and determine if your location could benefit by using outside air for cooling.
- ★ E28.5 Organizations such as TerraPass and Carbonfund.org sell CO₂ “offsets” through which organizations can compensate for their carbon emissions. For example, one common strategy used by offsetters is to subsidize the development of carbon-neutral energy sources (e.g., solar and wind power), with the goal of reducing future emissions.

These programs have proved controversial. Some observers doubt the reality of the claimed emission reductions, while others question the programs on philosophical grounds.⁷

Select a specific carbon offset provider and assess the plausibility of the strategies it is pursuing. Are the programs sufficiently well documented that you could make your own evaluation of their quality? Has any impartial group evaluated this provider, and if so, what were their conclusions?

7. WordPress developer Mark Jaquith wrote, “It’s like killing a person, and then convincing a murderer to kill one less person. You didn’t negate your murder. You still killed the person. Convincing someone else to reduce their emissions doesn’t make up for your emissions.” We don’t necessarily endorse this view, but it is representative the anti-offset perspective.