Green Computing

Tools and Techniques for Saving Energy, Money, and Resources

Bud E. Smith

CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business
AN AUERBACH BOOK

Green Computing Tools and Techniques for Saving Energy, Money, and Resources
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International Standard Book Number-13: 978-1-4665-0340-3 (Hardback)

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

Printed on acid-free paper
Version Date: 20130531

International Standard Book Number-13: 978-1-4665-0340-3 (Hardback)

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http://www.taylorandfrancis.com

and the CRC Press Web site at
http://www.crcpress.com

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Chapter 7

Green Servers and Data Centers

Key Concepts

This chapter describes how to green your data center(s) and servers:

- Choosing green suppliers when you buy in data center services
- Why you should start now
- Planning buildings
- Planning power supplies
- Servers, storage, and networking

7.1 Choosing and Creating Green Data Centers

More and more of the intelligence and information used by a computing system is housed away from the primary device itself. This is simply a return to a past reality, and perhaps the future will see another swing of the pendulum.

In the mainframe computer era, computing took place on large computers—mainframes. As computer technology grew more powerful and less expensive, minicomputers became another option. Users interacted with dumb terminals—dumb because they had no processing power nor storage of their own.

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Some of us will remember the IBM 3270 series of terminals, with green-on-black, text-only screens, as a standard.

The microcomputer era, beginning in the 1980s, placed computer processing power and storage directly on the user's desktop (oftentimes alongside a 3270 or other terminal). Early data sharing took place by carrying floppy disks from one PC to another, which was called "sneakernet." The rise of personal computer networking began the process of easier sharing of work and messages among microcomputers.

Now, we are turning nearly full circle. More and more computing work is done on servers—some located inside an organization, others outside, in what is now known as cloud computing or Software as a Service (Saas). In many cases, the user's device—whether a smartphone, tablet, or personal computer—just provides the user interface for processing and data that happen in the cloud.

But "the cloud" is really a collection of a whole bunch of clouds. Companies such as Google, Facebook, and Apple compete on the basis of the power, low cost—and, increasingly, green credentials—of their data centers. Even mainframe computers are now sold as particularly large and capable servers.

Google, in particular, has become known for its unique server and data center design, which saves energy and expense. This has been said to give Google a cost advantage of perhaps 30% per processing operation, compared to competitors. The accompanying power savings are inherently green, and Google is pressing its advantage in this area.

Google, going much further than its competitors, is even a significant investor in renewable energy. Google also pioneers potentially green technologies, such as the Google Car. (Cars would be far more efficient if driven by computers.)

Given the emerging nature of distributed computing, your first opportunity to green your data center(s) is to outsource as much data center–type processing as possible. For example, if you use Google Apps heavily in your organization, you've just chosen to have much of your data center work done outside your company. The same goes for every SaaS application that you buy (e.g., Salesforce.com).

Some vendors even give you a choice. Microsoft's competing Customer Resource Management, or CRM, application is called Microsoft Dynamics CRM. It comes in both an internally hosted version and a cloud-based version, called Microsoft Dynamics CRM Online.

Use green criteria to help determine what software services to buy in from outside and which ones to perform in house. Give preference to green vendors, using criteria similar to those described for green devices in the previous chapter. This is the easiest way to green much of your data center efforts—by outsourcing them. Outside vendors will usually be "greener" than you can easily manage, because they have such large efficiencies of scale compared to you. You can also use additional green criteria in choosing SaaS software vendors.

Amazon is famous for selling books, but savvy IT managers know that it is also the leading provider of scalable computing services. These services are called Amazon Web Services, or AWS for short. AWS is as close as you can come to getting your processing and storage services in a way that is similar to buying electricity. AWS is flexible and reasonably priced, for most purposes.

Google is working hard to catch up. With either of these providers, computing power becomes a utility, like electrical power: you just plug into it as needed; then you pay a bill at the end of the month, depending on how much you use. (The Amazon approach comes closest to this, as it's more flexible in terms of the tools you can use in crafting solutions.)

To green your entire operation, follow the same approach for computing services that you use with computing devices: move services to the greenest, least impactful approach first (someone else's green data center); then to the next most impactful one (your own green data center); and, only as a last resort, to the most impactful one—your own non-green data center, or local processing on the users' own devices.

Even if you decide to run servers yourself, they don't need to be servers you own, nor do the servers need to run in space you own and operate directly. Rackspace (see Figure 7.1) is one of the best-known of many companies providing

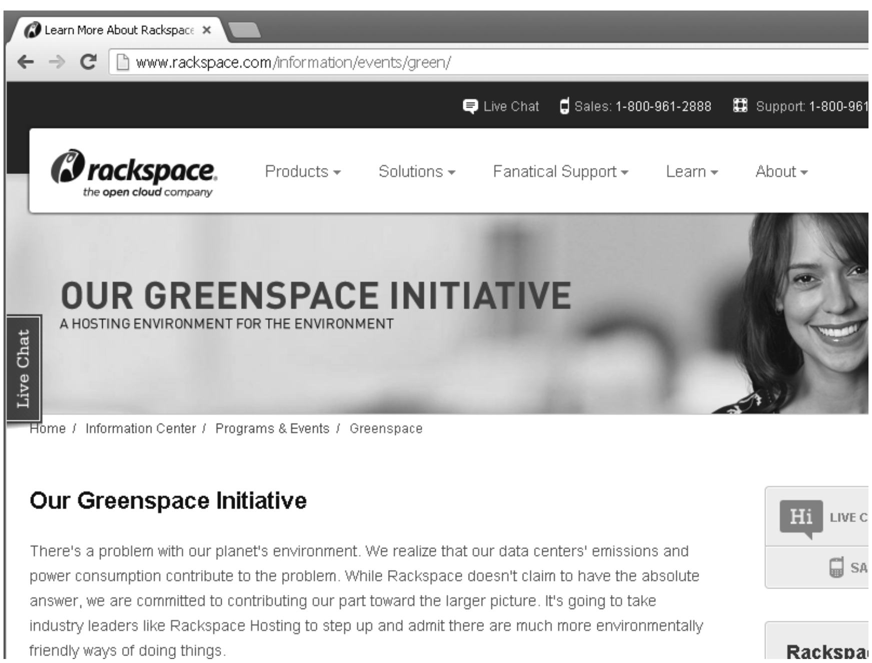

Figure 7.1 Rackspace is a leader in Green Data Center Hosting.

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server facilities for hire, and they have a robust green program. Consider using offsite hosting for your services where possible.

7.2 Green Data Centers as a Model

Data centers have been estimated to use between 1% and 1.5% of the world's total energy, according to an article in the IEEE's *IT Professional*.[1] Data center facilities use more than 100 times the energy than standard office buildings, according to the US Department of Energy.[2]

Your internally owned and operated data center, or centers, are the most visible and most expensive physical investment your IT department will make. Hardware costs are usually only a part of the total, and may be less than the associated software, management, facilities, and cooling costs. However, they still represent a large investment all by themselves. Hardware investments also set the terms and direction of all the related investments you make.

Data centers also take time to plan, build (if you build your own), and equip. Launching a new data center can be a big event, if you choose to make it one.

Adding green considerations to your data center planning, or implementing green efforts for existing data centers, are expensive efforts up front and may seem like distracting ones as well. But they're at the core of what you do as an IT manager. They're also likely to save money, not cost money, over the lifetime of a data center.

I mentioned in the previous chapter that "failure to supply" is a chief failing of many businesses, and a service organization such as an IT department can also "fail to supply" services that meet the shifting needs of internal customers. These internal customers and other stakeholders are increasingly expecting "greening" of the IT services they depend on. You may be asked to lead this move, follow others' efforts, or get out of the way.

The Green and Virtual Data Center, by Greg Schulz,[3] goes into a great deal of useful detail about what it takes to create and run a data center that's, well, green and virtual. I'll introduce some of the key concerns in this chapter; please use the Schulz book for greater detail.

7.3 The Last Shall Be First . . .

Because data centers represent such a large investment, it's tempting to defer greening them until you get some experience with, say, buying green laptops. I recommend that you start right away. Individual computing devices come and go, with a useful life of, at least, a few years. But data center–related decisions

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are serious infrastructure decisions. You'll be living with them for years, even decades to come. Green decision making also takes place on a learning curve. Many more possibilities open up as you gain momentum. The longer you wait to start, the fewer possibilities you'll have in the years ahead.

Even a decision to outsource computing capability has long-term effects. Let's say you decide to use Salesforce.com instead of an on-premise solution. Once you make that commitment, it's highly likely that people at your company will be using Salesforce 10, 20, even 30 years down the road.

If you choose a data center architecture that's as green as possible now, and keep greening it, you open up a lot of possibilities for progress. If you proceed without working green considerations into your plans, though, you cut off all sorts of opportunities for improvement. At the same time, be careful not to overinvest in data center infrastructure. Look at your likely needs many years down the road, especially with SaaS and outside hosting as more and more important players in the computing landscape.

Rightsize your "hard" investments so that your use of traditional "green"—money, that is—can be as effective and farsighted as your support for green computing efforts.

7.4 What Makes a Data Center Green?

For a data center, green means two fairly different things:

1. Mainstream environmental and sustainability issues, such as those on which most of this book is based
2. Power, cooling, floor space, and environmental health and safety issues, abbreviated as PCFE

Mainstream environmental issues and PCFE concerns often lead to the same destination. However, you can pursue PCFE goals without any concern for the environment as a whole. PCFE is more about efficient use of resources and worker safety, which are more traditional organizational concerns than environmental and sustainability issues.

PCFE arises from the fact that demands on IT, and therefore on data centers, seem to always only escalate. Without PCFE, a data center could become extraordinarily large, need impractical amounts of power or cooling, and constitute an unsafe environment—and still face demands to grow further. PCFE is an effort to keep data centers manageable, in both the colloquial and business senses of the term.

To make a green data center, combine PCFE concerns with mainstream environmental and sustainability efforts, as described throughout this book.

That way you get all the benefits of both approaches, without that much additional effort from just using one or the other.

Another factor that makes a data center green is virtualization. Virtualization separates what you do to manage computing resources from the actual physical resources at hand. For instance, a software-based virtual machine allows you to host several application servers and/or Web servers on a single physical machine—or to host a single application server on several physical machines, if demand requires it.

Virtualization seeks to enable you to view your computing resources as a single pool, ready to serve your software, storage, and processing demands as needed. This avoids duplication of equipment and waste. Although technical in its details, the effects of virtualization are very green indeed.

7.5 Building and Power Supply Considerations

Let's consider the exercise of building a new data center from scratch, with nothing determined up front except the likely needs of your company. You may actually be making decisions in a more constrained environment; for instance, you may be looking at taking up another floor in an existing office building, rather than doing a new build. Even so, looking at how to build up the data center from a clean slate will inform your overall approach.

In planning a building, you're going to juggle half a dozen factors:

- **Floor space.** What's the most floor space you can expect to use?
- **Power.** How much power can you get from the local utility in an area without paying exorbitant rates?
- **Cooling.** How much cooling will you need for a given amount of power consumption on a given amount of floor space?
- **Health and safety.** What are key health and safety concerns for your data center, such as exhaust from servers or printers? Are there particular sensitivities in a given local area, for instance, due to recent problems of a specific kind?
- **Device power consumption.** Given a certain budget of floor space, power availability, and/or cooling capacity, how many of what kind of devices can you have?
- **Organizational computing needs.** How much of your organization's needs will the data center be able to meet? How can you meet any needs over that limit?
- **Tripwires.** How can you set up early warning systems when you start approaching a data center's limits, so you have plans in place to prevent running up against them?

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Now the model doesn't exist that allows you to simply treat all these numbers as unlimited, then juggle combinations of them. You have to start assuming some factors, then see how others are affected. You can pick a geographic location, for instance, and find out what the local utility can do for you in terms of power supply. You can assess cooling needs based on that area's weather and some assumed amount of floor space and mix of devices on that space.

One useful exercise is to plan initially for a one-story building, running all the numbers for a given amount of floor space on a single floor. Figure out cooling, device mix, and so on. Then make sure you can add more floors, as needed, to meet growth in your needs.

Even more valuable is to find existing data centers, either within your organization or outside it, that you can use as models. The mix of needs served, software applications used, and so on should be as similar to your own as possible. (And the task of finding a comparison site will be easier, the more up-to-date your own approach is.)

7.6 Servers, Storage, and Networking

In planning your data center, you need to plan for servers (for application and Web processing), storage, and networking—among your servers and storage devices, and to connect with the world outside the data center.

The storage and networking components depend on the decisions you make for servers, so I'll primarily focus here on server options. For more on all three of these elements, and much else besides, see *The Green and Virtual Data Center*.[3]

The first (and greenest) option to consider for servers is to use someone else's. When you do need to buy servers, though, you can help yourself with careful planning.

Servers are typically the largest single user of power in a data center, directly or indirectly. (The biggest power bill will be for cooling, but an outsize part of the cooling needs are generated by the servers.)

Servers stop working when they get too hot. Server manufacturers will give you a recommended temperature range that you have to stay within.

The biggest problem for your servers and your costs is the same problem utilities have: what to do on the very hottest days of the year, when air conditioning loads—and, often, electricity rates—go through the roof. Many utilities will pay you good money to take demand offline during these peaks, but taking your data center down is hard to explain to your stakeholders. If you have two data centers in widely different locations, though, you can juggle demand between them during peaks.

Here are tradeoffs you make when choosing a server at a given performance level:

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- Physical size—small is good.
- Power usage—less is good.
- Heat output—less is good.
- Flexibility—the more one type of server can do, the fewer different types of equipment you need to support. The more different ways a server can be "racked" in different cabinet configurations, the more you can do with scores or even hundreds of servers.

While "less is more" for size, power, and heat output, the priority of each depends on your circumstances. If you have a facility in a cold place—some data centers are placed underground, cheek by jowl with icebergs—heat output may not be your biggest problem. You might have an air-cooled facility that can only take away so much heat, but plenty of floor space for devices. Power usage should always be minimized, though; it helps with cooling as well as direct power bills, and also reduces risk from potential increases in energy costs.

Flexibility is crucial. Virtualization and green solutions are both easier to implement if you have a well-understood hardware base. Using fewer different types of devices makes it easier to understand and manage your hardware base.

Along with servers themselves, consider clustering software. Clusters can be managed more easily than single servers, and clusters can serve specialized purposes, such as high-performance computing or heavy input/output (I/O). A cluster can be active, or placed on standby for use when needed. A grid is quite similar to a cluster, and any difference may be more marketing spin than substance.

Once you make progress on server and grid/clustering solutions, you can see how those decisions affect storage needs. Solutions range from solid-state storage, through hard disks, tape, optical, and more. Within each type of storage, and across the different types, you're trading off read speeds, write speeds, capacity, and expense.

Be aware that storage needs are increasing exponentially. Regulatory requirements are one reason. It's increasingly important that you keep, for instance, many years' worth of email exchanges for regulatory purposes.

Another problem—oops, I mean opportunity—is deep data. This means, for instance, storing every action each user takes on your website for months and years at a time, then analyzing the traces for insights. Often, management wants data stored just in case they want to do a data dive later—but doesn't like seeing the resulting bills.

A crucial differentiator for organizations today is their ability to mine vast archives of data for information that contributes to sales and marketing, even product development and support effectiveness. However, you can't mine vast archives of data if you've thrown it away. Keeping this information cost-effectively, for either planned or unknown future uses, is a bit of an art form.

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Storing huge amounts of data that you would otherwise just delete, then churning through it repeatedly in the hope that something interesting turns up, is not inherently very green. Nor is it very efficient; one company I work with throws away "trivial" data after 90 days to save server space and speed up processing. Clearly, there are a lot of choices to make here.

Storage can be divided into tiers: very fast, very expensive; fairly fast, fairly expensive; slow and inexpensive. Each technology type can be used in one or more of these tiers. Data compression can optimize your usage within a tier, or across tiers. You also need to consider remote backup of all of your data, all of the time, and whether additional compression is risky for archived data. With all this, you need to consider PCFE and mainstream green concerns as well.

Networking capabilities are similar in structure to data storage: You have very fast networking for interconnections among servers, then a grid of fast networking within the data center, then slower connections to and from the outside world.

7.7 Data Center Suppliers

You can use all kinds of suppliers for data centers. (I continue to refer to actual, physical data centers that you own or lease directly.) Suppliers will do all of the work for you, and you only need to approve a Request for Proposal and write a check. Or, you can own and manage as much or little of the process as you'd like.

If you choose a green-oriented supplier, you may be able to get a lot of benefits without too much work—including, again, risk reduction from reduced exposure to energy price increases. You can let a supplier do a great deal of the work on one data center, then use what you learn to do more of the job yourself in additional data centers later.

As with end-user computing devices, you need to consider the green credentials of data center device suppliers as well. A simple comparison is to use relatively green devices from highly rated suppliers in the end-user world as a benchmark for devices from more specialized makers. At this writing, HP is the leader in the Greenpeace Guide to Greener Electronics, and they certainly make servers. You can thus use HP servers as a "green" reference comparison for competing bids. (Tell the other vendors that you're doing this, and why; it will drive them nuts, but you'll get better bids.)

And, as your data center specifications firm up, you can compare one last time to outsourced approaches. These include outsourced processing and storage capabilities from the likes of Amazon and Google. Odds are, you can't handle all your needs via outsourcing. However, you may be able to do a lot.

In fact, for a medium or large organization, you probably always want to use a mix of solutions—SaaS and internally hosted software; data centers you own

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and computing capability that you rent. That way you can flexibly shift your assets around as opportunities present themselves. If you don't use a modicum of, say, Amazon services for anything at all, you won't be ready to use them for a big project when an otherwise suitable opportunity presents itself.

Building, owning, managing, and improving data center resources is a huge challenge, and doing so in a green computing–savvy manner that also meets PCFE concerns makes things even more complex. The rewards, though, are commensurate with the challenge.

7.8 Summary

This chapter described how to green your data center(s) and servers: choosing green suppliers; planning buildings; planning power supplies; choosing servers, storage, and networking; and understanding why you should start now. The next chapter discusses the hardware life cycle and reducing hardware impact in depth.

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