Chapter 1

IT Data Center Economic and Ecological Sustainment

Separating green washing and green issues in IT is the green gap.

In this chapter you will learn:

- The many faces of green information technology (IT) in data centers
- How to close the green gap and enable solutions to address IT issues
- IT data centers dependencies on electrical power
- Myths and realities pertaining to power, cooling, floor space, and environmental health and safety (PCFE)
- What green washing is and how to develop a PCFE strategy to address it
- Differences between avoiding energy use and being energy efficient
- Various techniques, technologies, and approaches to address PCFE issues

1.1 The Many Faces of Green—Environmental and Economic

In order to support business growth and ensure economic sustainability, organizations of all sizes need to establish a strategy to address the impact of their **power, cooling, floor space, and environmental health and safety (PCFE)** needs. PCFE addresses the many different facets of being green for **information technology (IT)** data centers, as shown in Figure 1.1, including emissions as a result of electricity energy production; cooling of IT equipment; efficient use of floor space; power for uninterruptible power supplies (UPS), backup, electricity **generation and transmission (G&T),** cost of power, and supply/demand; and disposal (removal of hazardous substances, waste electrical and electronic equipment, adherence to the LEED

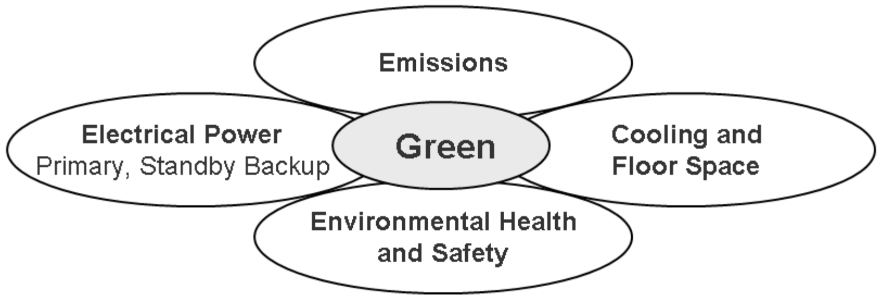

Figure 1.1 Green in IT Data Centers

[Leadership in Energy and Environmental Design] program). **Environmental health and safety (EHS)** topics include elimination of hazardous substances, traditional and e-waste disposal, and recycling. In addition to supporting growth, the business benefits include the abilities to leverage new and enhanced information services, enable business agility, and improve on cost effectiveness to remain competitive while reducing effects on the environment.

As a society, we have a growing reliance on storing more data and using more information-related services, all of which must be available when and where needed. Data and related information service are enabled via IT services including applications, facilities, networks, servers, and storage resources referred to collectively as an IT data center. As a result of this increasing reliance on information, both for home and personal use as well as business or professional use, more data is being generated, stored, processed, and retained for longer periods of time.

Energy costs are rising, floor space is at a premium in some organizations or will soon be exhausted in others. Cooling and electrical power distribution capabilities are strained or at their limits. Existing and emerging regulations for EHS as well as for emissions and energy efficiency are appearing. All of these factors continue to stress an aging infrastructure, which affects business growth and economic sustainment, resiliency, availability, and operations cost complexity. Meanwhile, businesses of all sizes have a growing dependence on availability and timely access to IT resources and data.

Telephone services, 911 emergency dispatches, hospitals and other critical services, including your favorite coffee house and the electrical power utilities themselves, rely on information services and the reliable supply of electrical power to sustain their existence. Not only is more data being generated, more copies of data are being made and distributed for both active use by information consumers and for data protection purposes, all resulting in an expanding data footprint. For example, when a popular document, presentation, photo, audio, or video file is posted to a website and subsequently downloaded, the result is multiple copies of the document being stored on different computer systems. Another common example of an expanding data footprint is the many copies of data that are made for business continuance, disaster recovery, or compliance and archiving purposes to protect and preserve data.

1.2 The Growing Green Gap: Misdirected Messaging, Opportunities for Action

The combination of growing demand for electricity by data centers, density of power usage per square foot, rising energy costs, strained electrical G&T infrastructure, and environmental awareness prompted the passage of U.S. Public Law 109-431 in 2006. Public Law 109-431 instructed the U.S. Environmental Protection Agency (EPA), part of the Department of Energy, to report to Congress on the state of IT data centers' energy usage in the United States.

In the August 2007 EPA report to Congress, findings included that IT data centers (termed information factories) in 2006 consumed about 61 billion kilowatt-hours (kWh), or 61 billion times 1,000 watt-hours of electricity, at an approximate cost of about $4.5 billion. It was also reported that IT data centers, on average, consume 15 to 25 times (or more) energy per square foot compared to a typical office building. Without changes in electricity consumption and improved efficiency, the EPA estimates that IT data centers' power consumption will exceed 100 billion kWh by 2011, further stressing an already strained electrical G&T infrastructure and increasing already high energy prices.

There is a growing "green gap" or disconnect between environmentally aware, focused messaging and core IT data center issues. For example, when I ask IT professionals whether they have or are under direction to implement green IT initiatives, the number averages below 20%. However, when I ask the same audiences who has or sees power, cooling, floor space, or EHS-related issues, the average is 80–90%. I have found some variances in

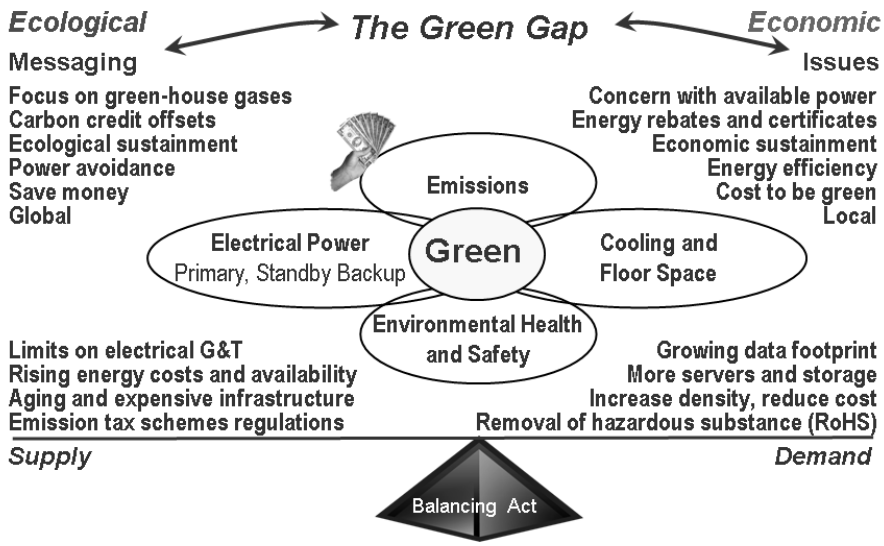

Figure 1.2 The Green Gap, Together with Supply and Demand Drivers

geography of IT people across the United States, as well as around the world, which changes the above numbers somewhat; however, the ratios are consistent. That is, most IT professionals relate being "green" with other items as opposed to making the link to PCFE topics. Not surprisingly, when I talk with vendors and others in the industry and ask similar questions, there is usually an inverse response, further indicating a green gap or messaging disconnects.

The growing green gap is, in its simplest terms, one of language and messaging. Although there is a common denominator or linkage point of green among data center issues, there is often a disconnect between needs centered on PCFE footprint and related costs as well as the need to sustain business growth. Building on Figure 1.1, Figure 1.2 shows common environmental messaging on the left and common IT issues shown on the right. Also in Figure 1.2, on the lower left, are supply constraints, with some demand drivers shown in the lower right. Specific issues or combinations of issues vary by organization size, location, reliance on and complexity of IT applications, and servers, among other factors.

IT organizations in general have not been placing a high priority on being perceived as green, focusing instead on seemingly nongreen PCFE issues. Part of the green gap is that many IT organizations are addressing (or need to address) PCFE issues without making the connection that, in fact;

they are adopting green practices, directly or indirectly. Consequently, industry messaging is not effectively communicating the availability of green solutions to help IT organizations address their issues. By addressing IT issues today that include power, cooling, and floor space along with asset disposal and recycling, the by-products are economic and ecologically positive. Likewise, the shift in thinking from power avoidance to more efficient use of energy helps from both economic and ecological standpoints.

There is some parallel between the oil crisis of the 1970s and the current buzz around green IT and green storage along with power, cooling, and floor space issues. During the 1970s oil crisis, there was huge pressure to conserve and avoid energy consumption, and we are seeing similar messaging around power avoidance for IT, including consolidation and powering down of servers and storage systems.

Following the initial push for energy conservation in the 1970s was the introduction of more energy-efficient vehicles. Today, with IT resources, there is a focus on more energy-efficient servers and storage, for both active and inactive use or applications, which also incorporate intelligent power management or adaptive power management along with servers and storage that can do more work per watt of energy. The subsequent developments involve adopting best practices including better data and storage management, archiving, compression, de-duplication, and other forms of data footprint reduction, along with other techniques to do more with available resources to sustain growth.

1.3 IT Data Center "Green" Myths and Realties

Is "green IT" a convenient or inconvenient truth or a legend? When it comes to green and virtual environments, there are plenty of myths and realities, some of which vary depending on market or industry focus, price band, and other factors. For example, there are lines of thinking that only ultralarge data centers are subject to PCFE-related issues, or that all data centers need to be built along the Columbia River basin in Washington state, or that virtualization eliminates vendor lock-in, or that hardware is more expensive to power and cool than it is to buy. The following are some myths and realities as of today, some of which may be subject to change from reality to myth or from myth to reality as time progresses.

- *Myth:* Green and PCFE issues are applicable only to large environments.
  - *Reality:* I commonly hear that green IT applies only to the largest of companies. The reality is that PCFE issues or green topics are relevant to environments of all sizes, from the largest of enterprises to the small/medium business, to the remote office branch office, to the small office/home office or "virtual office, all the way to the digital home and consumer.
- *Myth:* All computer storage is the same, and powering disks off solves PCFE issues.
  - *Reality:* There are many different types of computer storage, with various performance, capacity, power consumption, and cost attributes. Although some storage can be powered off, other storage that is needed for online access does not lend itself to being powered off and on. For storage that needs to be always online and accessible, energy efficiency is achieved by doing more with less, that is, boosting performance and storing more data in a smaller footprint using less power.
- *Myth:* Servers are the main consumer of electrical power in IT data centers.
  - *Reality:* In the typical IT data center, on average, 50% of electrical power is consumed by cooling, with the balance used for servers, storage, networking, and other aspects. However, in many environments, particularly processing or computation-intensive environments, servers in total (including power for cooling and to power the equipment) can be a major power draw.
- *Myth:* IT data centers produce 2% of all global carbon dioxide (CO_2) emissions.
  - *Reality:* This is perhaps true, given some creative accounting and marketing math. The reality is that in the United States, for example, IT data centers consume around 2–3% of electrical power (depending on when you read this), and less than 80% of all U.S. CO_2 emissions are from electrical power generation, so the math does not quite add up. However, if no action is taken to improve IT data center energy efficiency,

continued demand growth will shift IT power-related emissions from myth to reality.

- *Myth:* Server consolidation with virtualization is a silver bullet to address PCFE issues.
  - *Reality:* Server virtualization for consolidation is only part of an overall solution that should be combined with other techniques, including lower power, faster and more energy-efficient servers, and improved data and storage management techniques.
- *Myth:* Hardware costs more to power than to purchase.
  - *Reality:* Currently, for some low-cost servers, standalone disk storage, or entry-level networking switches and desktops, this may be true, particularly where energy costs are excessively high and the devices are kept and used continually for three to five years. A general rule of thumb is that the actual cost of most IT hardware will be a fraction of the price of associated management and software tool costs plus facilities and cooling costs.

Regarding this last myth, for the more commonly deployed external storage systems across all price bands and categories, generally speaking, except for extremely inefficient and hot-running legacy equipment, the reality is that it is still cheaper to power the equipment than to buy it. Having said that, there are some qualifiers that should also be used as key indicators to keep the equation balanced. These qualifiers include the acquisition cost; the cost, if any, for new, expanded, or remodeled habitats or space to house the equipment; the price of energy in a given region, including surcharges, as well as cooling, length of time, and continuous time the device will be used.

For larger businesses, IT equipment in general still costs more to purchase than to power, particularly with newer, more energy-efficient devices. However, given rising energy prices, or the need to build new facilities, this could change moving forward, particularly if a move toward energy efficiency is not undertaken.

There are many variables when purchasing hardware, including acquisition cost, the energy efficiency of the device, power and cooling costs for a given location and habitat, and facilities costs. For example, if a new storage solution is purchased for $100,000, yet new habitat or facilities must be built for three to five times the cost of the equipment, those costs must be figured into the purchase cost. Likewise, if the price of a storage solution decreases dramatically, but the device consumes a lot of electrical power and needs a large cooling capacity while operating in a region with expensive electricity costs, that, too, will change the equation and the potential reality of the myth.

1.4 PCFE Trends, Issues, Drivers, and Related Factors

Core issues and drivers of green IT include:

- Public consumer and shareholder or investor environmental pressures
- Recycling, reducing, and reusing of resources, including safe technology disposition
- Increasing demand and reliance on information factories and available IT resources
- Limited supply and distribution capabilities for reliable energy
- Pressures from investors and customers to reduce costs and boost productivity
- Constraints on power distribution, cooling capabilities, and standby power sources
- Rising energy and distribution costs coupled with availability of energy fuel sources
- Growing global environmental and green awareness and messaging
- Enforcement of existing clean air acts along with reduction of energy-related emissions:
    - Greenhouse gasses, including CO_2 and nitrogen dioxide (NO_2)
    - Methane, water vapor, acid rain, and other hazardous by-products
- Emerging and existing EHS regulations or legislation standards and guidelines:
    - Enhancements to existing clean air act legislation

- The Kyoto Protocol for climate stability
- Emission tax schemes in Europe and other regions
- Removal of hazardous substances
- Waste electrical and electronic equipment
- U.S. Energy Star, European Union (EU), United Kingdom (UK) programs

The U.S. national average CO_2 emission is 1.34 lb/kWh of electrical power. Granted, this number will vary depending on the region of the country and the source of fuel for the power-generating station or power plant. Coal continues to be a dominant fuel source for electrical power generation both in the United States and abroad, with other fuel sources, including oil, gas, natural gas, liquefied propane gas (LPG or propane), nuclear, hydro, thermo or steam, wind and solar. Within a category of fuel for example, coal there are different emissions per ton of fuel burned. Eastern U.S. coal is higher in CO_2 emissions per kilowatt-hour than western U.S. lignite coal. However, eastern coal has more British thermal units (Btu) of energy per ton of coal, enabling less coal to be burned in smaller physical power plants.

If you have ever noticed that coal power plants in the United States seem to be smaller in the eastern states than in the midwestern and western states, it's not an optical illusion. Because eastern coal burns hotter, producing more Btu, smaller boilers and stockpiles of coal are needed, making for smaller power plant footprints. On the other hand, as you move into the midwestern and western states of the United States, coal power plants are physically larger, because more coal is needed to generate 1 kWh, resulting in bigger boilers and vent stacks along with larger coal stockpiles.

On average, a gallon of gasoline produces about 20 lb of CO_2, depending on usage and efficiency of the engine as well as the nature of the fuel in terms of octane or amount of Btu. Aviation fuel and diesel fuel differ from gasoline, as do natural gas or various types of coal commonly used in the generation of electricity. For example, natural gas is less expensive than LPG but also provides fewer Btu per gallon or pound of fuel. This means that more natural gas is needed as a fuel to generate a given amount of power.

Recently, while researching small, 10- to 12-kWh standby generators for my office, I learned about some of the differences between propane and natural gas. What I found was that with natural gas as fuel, a given generator produced about 10.5 kWh, whereas the same unit attached to a LPG or propane fuel source produced 12 kWh. The trade-off was that to get as much power as possible out of the generator, the higher-cost LPG was the better choice. To use lower-cost fuel but get less power out of the device, the choice would be natural gas. If more power was needed, than a larger generator could be deployed to use natural gas, with the trade-off of requiring a larger physical footprint.

Oil and gas are not used as much as fuel sources for electrical power generation in the United States as in other countries such as the United Kingdom. Gasoline, diesel, and other petroleum-based fuels are used for some power plants in the United States, including standby or peaking plants. In the electrical power G&T industry as in IT, where different tiers of servers and storage are used for different applications there are different tiers of power plants using different fuels with various costs. Peaking and standby plants are brought online when there is heavy demand for electrical power, during disruptions when a lower-cost or more environmentally friendly plant goes offline for planned maintenance, or in the event of a "trip" or unplanned outage.

CO_2 is commonly discussed with respect to green and associated emissions. Carbon makes up only a fraction of CO_2. To be specific, only about 27% of a pound of CO_2 is carbon; the balance is not. Consequently, carbon emissions taxes, as opposed to CO_2 tax schemes, need to account for the amount of carbon per ton of CO_2 being put into the atmosphere. In some parts of the world, including the EU and the UK, **emission tax schemes (ETS)** are either already in place, or are in initial pilot phases, to provide incentives to improve energy efficiency and use. Meanwhile, in the United States there are voluntary programs for buying carbon offset credits as well as initiatives such as the Carbon Disclosure Project. The Carbon Disclosure Project (www.cdproject.net) is a not-for-profit organization that facilitates the flow of information about emissions to allow managers and investors to make informed decisions from both economic and environmental perspectives. Another voluntary program is the EPA Climate Leaders initiative, under which organizations commit to reduce their greenhouse gas emissions to a given level or within a specific period of time.

These voluntary programs can be used to offset carbon emissions. For example, through organizations such as Terrapass (www.terrapass.com), companies or individuals can buy carbon credits to offset emissions from home or business energy use. Credits can also be bought to offset emissions associated with travel or automobile use. Money from the sale of carbon offset credits is applied to environmental clean-up, planting of trees, and other ways of reducing climate change. Carbon credits are also traded like traditional securities and commodities via groups such as the Chicago Climate Exchange (www.chicagoclimateexchange.com). One way of thinking about carbon credits is to consider them the way you would a parking or speeding ticket: What would it take (stiffer fines, jail time) to make you change your driving habits?

A controversial use of carbon credits is associated with green washing," the practice of using carbon credits to offset or even hide energy use or lack of energy efficiency. For example, if many individuals fly on their own or charter jet aircraft as opposed to flying on commercial aircraft, on which emissions are amortized across more passengers, carbon offsets are a convenient way of being perceived as carbon neutral. For a relatively older plane such the Boeing 757, a late 1970s-era twin-engine design, which can carry about 150 passengers and crew on a 1,500-mile flight, the average fuel used per passenger for a flight of just over three hours is in the range of 65 mpg per passenger. For a larger and newer more fuel-efficient aircraft, which can carry more passengers over longer distances, the average miles per gallon per passenger may be closer to 75 mpg if the plane is relatively full. On the other hand, if the same airplane is half-empty, the miles per gallon per passenger will be lower.

If you are concerned about helping the environment, there are options including planting trees, changing your energy usage habits, and implementing more energy-efficient technology. A rough guideline is that about one forested acre of trees is required to offset 3 tons of CO_2 emissions from electrical power generation. Of course, the type of tree, how densely the acre of trees is planted, and the type of fuel being used to produce electrical power will alter the equation. Energy costs vary by region and state as well as from residential to business, based on power consumption levels. Some businesses may see a base rate of, for example, 12 cents/kWh used, which jumps to 20 cents/kWh after some number of kWh used each month.

Energy costs also need to reflect cooling costs, which typically account for about half of all power consumed by IT data centers. A typical gallon of gasoline (depending on octane level) will, on average, generate about 20 lb of CO_2. Approximately (this number is constantly changing) 78% of CO_2 emissions in the United States are tied to electrical power generation. Carbon offset credits can sell for in the range of $250/lb up to 10 tons of CO_2 and $200/lb for larger quantities up to 35 tons of CO_2.

The importance of these numbers and metrics is to focus on the larger impact of a piece of IT equipment that includes in its cost not only energy consumption but also other hosting or site environmental costs. Energy costs and CO_2 emissions vary by geography and region, as does the type of electrical power used (coal, natural gas, nuclear, wind, thermal, solar, etc.) and other factors that should be kept in perspective as part of the big picture.

Some internal and external motivators driving awareness and discussion of green IT and the need to address PCFE issues include:

- Family and philanthropic motive versus economic business realties
- Debates between science and emotions, and the impact of politics and business realities
- Cost savings or avoidance, or when to spend money to save larger amounts of money
- Evolving awareness of green global supply chains and ecosystems

Internal and external stakeholders or concerned entities include:

- Customers and employees concerned about EHS or energy savings
- Public concern about climate change, recycling, and removal of hazardous substances
- Investors and financial communities looking to avoid risk and liabilities
- Governmental and regulatory bodies enforcing existing or emerging legislation
- General public relations to protect and preserve a businesss image and reputation

Given the many different faces of green and PCFE issues, regulations and legislation vary by jurisdiction and areas of focus. For example, under the Kyoto Protocol on climate change control, not all nations have indicated how they will specifically reduce emissions. Some countries and regions, including the UK, the EU, and Australia, either have deployed or are in the process of launching ETS programs. In the United States there are voluntary programs for buying carbon emissions offsets along with energy-efficiency incentives programs. There is, however, as of this writing, no formal country-wide ETS.

1.5 Closing the Green Gap for IT Data Centers

In order to support the expanding data footprint and reliance on timely information services, more servers, storage, networks, and facilities are required to host, process, and protect data and information assets. IT data centers, also known as information factories, house, process, and protect the information we depend on in our daily lives.

A common challenge for enabling continued access to information faced by IT data centers of all sizes, regardless of type, business, or location, is cost containment. Over the past decades, technology improvements have seen computers reduced to a fraction of the physical size, weight, cost, and power consumption formerly needed, while providing an exponential increase in processing capability. Data storage technologies, including magnetic disk drives, have also seen a similar decline in physical size, weight, cost, and power consumption, while improving on available storage capacity, reliability, and, in some cases, performance. Likewise, networks have become faster while requiring a smaller footprint, both physically and in terms of power required to operate the equipment. Even with technology improvements, however, the demand and subsequent growth rate for information-related services are outpacing the supply of reliable and available PCFE footprints.

For example, wake up in the morning and turn on the news, on the radio, TV, or Internet, and you are relying on the availability of information resources. The newspaper that you may read, your email, Instant Messages (IM) or text messages, voice mail, phone calls regardless of whether on a traditional landline phone, cell phone, or Internet-based phone service rely on information services. In the workplace, reliance on information services becomes more apparent, ranging from office to factory environments; travel depends on reservations, scheduling, weights and balance, dispatch and control systems. These are just a few examples of our dependence on available information. A few more examples include reliance on information services when you go shopping, whether online or in person at a large megastore store, or to the corner market; regardless of size, there are credit card processing, barcode labels or radio frequency ID (RFID) tags to read at checkout and for inventory.

Throughout this book, additional examples will be presented. However, for now, one last example of our growing reliance and use of information services is how much personal data exists in your home. That is, add up the amount of data, including digital photos, iTunes or MP3 audio files such as CDs and DVDs, either “ripped” onto a computer disk drive or in their native format, other documents on your personal digital assistants (PDAs), cell phones, and TiVo or digital video recorders (DVRs). For those who have a computer at home along with a cell phone and a digital camera, it is very likely that there exists at least 100 gigabytes (GB) of personal information that is, 100,000,000,000 characters of information. For many households, that number is closer to if not already exceeding 1,000 GB or 1 terabyte of data or 1,000,000,000,000 characters of information.

Even with the advent of denser IT equipment that does more in a given footprint, the prolific growth rate and demand for existing along with new rich media applications and data outpace available PCFE footprints. The result is a growing imbalance between supply of affordable and reliable power distribution where needed and the increasing demand and reliance on information services. Put another way, organizations that rely on information services need to sustain growth, which means more data being generated, processed, stored, and protected, which has a corresponding PCFE footprint impact.

IT services consumers are increasingly looking for solutions and products that are delivered via companies with green supply chains and green ecosystems. Green supply chains extend beyond product logos with green backgrounds or pictures of green leaves on the packaging to simply make you feel good about going green.

Regardless of stance or perception on green issues, the reality is that for business and IT sustainability, a focus on ecological and, in particular, the corresponding economic aspects cannot be ignored. There are business benefits to aligning the most energy-efficient and low-power IT solutions combined with best practices to meet different data and application requirements in an economic and ecologically friendly manner.

For example, by adopting a strategy to address PCFE issues, benefits include:

- Business and economic sustainment minimizing risk due to PCFE compliance issues
- Avoidance of economic loss due to lack of timely and cost-effective growth
- Reduction in energy-related expenses or downtime due to loss of power
- Compliance with existing or pending EHS legislation or compliance requirements
- Realization of positive press and public relations perception by consumers and investors
- Maximization of investment in facilities, floor space, cooling, and standby power
- Increasing business productivity and value with enhanced information systems
- The ability to adapt to changing economic and business conditions in a timely manner
- Leveraging of information systems as a core asset as opposed to a business cost center

As consumers in general are becoming aware of the many faces and issues associated with being green, there is also a growing skepticism about products, services, and companies that wrap themselves in green marketing. This has lead on a broad basis well beyond just the IT industry to the practice of "green washing, which involves "painting" a message "green" to appeal to the growing global green and environmental awareness phenomena. The challenge with "green washing" is that viable messages and important stories too often get lost in the noise, and, subsequently, real and core issues or solutions are dismissed as more "green noise. The "green washing" issue has become such a problem that traditional green-focused organizations such as Greenpeace have launched campaigns with websites (see, e.g., www.stopgreenwash.org) against the practice of "green washing" with slogans such as "Clean up your act, NOT your image."

Green initiatives need to be seen in a different light, as business enablers as opposed to ecological cost centers. For example, many local utilities and state energy or environmentally concerned organizations are providing funding, grants, loans, or other incentives to improve energy efficiency. Some of these programs can help offset the costs of doing business and going green. Instead of being seen as the cost to go green, by addressing efficiency, the by-products are economic as well as ecological. Put a different way, a company can spend carbon credits to offset its environmental impact, similar to paying a fine for noncompliance, or it can achieve efficiency and obtain incentives. There are many solutions and approaches to address these different issues, which will be looked at in the coming chapters.

Green and other energy, EHS, or PCFE or environmental power and cooling issues are a global concern for organizations of all sizes as well as for individuals. Issues and areas of focus and requirements vary by country and region. Some countries have more stringent regulations, such as specific guidelines for reducing energy consumption and CO_2 emissions or paying carbon offset credits, whereas in other countries the focus is on reducing costs or matching demand with energy availability.

Simply put, addressing PCFE issues or being green is an approach and practice for acquiring, managing, and utilizing IT resources to deliver application and data services in an economic and ecologically friendly manner for business sustainment. In going or being green, by improving IT infrastructure and resource efficiency, doing more with less, and maximizing existing PCFE and energy to become more ecological friendly, you also enable a business to grow, diversify, and expand its use of IT, all of which have economic benefits.

For example, you can spend money to become green by buying carbon offset credits while you continue to operate IT resources including servers, storage, and networks in an inefficient manner, or you can improve your efficiency by consolidating, boosting performance to do more work per unit of energy, reducing your PCFE impact and associated costs, and thus creating an economic benefit that also benefits the environment.

A challenge in identifying and addressing how effective solutions and approaches are toward being green is the lack of consistent or standard measurements, metrics, and reporting. For example, vendors may list energy used by hardware devices in many different ways, including watts, Btu, or amps for either the maximum circuit load, idle, active, or some other state such as a maximum configuration and workload. Some are measured; some are estimated or derived from a combination of measurements and component estimates.

Another factor tied to measuring energy use is how to gauge the effectiveness of the energy being used. For example, energy used for a tape drive and the tape is different then the energy used for a high-performance online storage system. Even when supposedly turned off or power down, many IT devices and consumer electronics still draw some power. Granted, the amount of power consumed in a standby mode may be a fraction of what is used during active use, but power is still being consumed and heat generated. For example, a server can be put into a sleep or low-power mode using a fraction of the electrical power needed when performing work. Another example is consumer electronics such as digital TVs that, even when turned off, still consume a small amount of electrical power. On the basis of an individual household, the power used is small; on a large-scale basis, however, the power consumption of standby mode use should be factored into analysis along with any subsequent power-on spikes or surges.

These issues are not unique to IT. There are good and interesting similarities to the automobile and transportation sectors in terms of benchmarks, metrics, usage scenarios, and classifications of vehicles. Another interesting correlation is that the automobile industry had to go into a conservation mode in the 1970s during the oil embargo, when supply could not keep up with demand. This led to more energy-efficient, less polluting vehicles, leading to where we are today, with hybrid technologies and better metrics (real-time for some vehicles) and fuel options and driving habits.

Another corollary is the trend to over consolidate to boost utilization at the expense of effective service delivery. For example, in some IT environments, servers are being consolidated with a focus on boosting utilization to avoid energy use independent of the subsequent effect on performance or availability. The same can be said for the trend toward shifting away from underutilized large vehicles to smaller, energy-efficient, and so-called green hybrid vehicles. For both automobiles and IT, some consolidation is needed, as are more energy-efficient solutions, better driving and usage habits, and alternative energy and fuel sources. However, for both automobiles and IT, the picture needs to be kept in focus: Performance, availability, capacity, and energy consumption need to be balanced with particular usage needs. Put another way, align the applicable resource to the task at hand.

While businesses generally want to do what is good, including what is good for the environment (or at least put up a good story), the reality is that its hard cold economics, particularly in the absence of regulations, that dictate how business operate. This is where the green gap exists between going green to be green or to save money, as opposed to achieving and maintaining economic growth while benefiting the environment. In addressing business economics and operations to avoid bottlenecks and expenses while also helping the environment, alternatives that happen to be green are seen as more appealing and affordable.

1.5.1 Energy Consumption and Emissions: Green Spotlight Focus

The advent of cheaper volume computer power has brought with it a tremendous growth in data storage. Until recently, the energy efficiency of servers, networks, software, and storage had been of little concern to IT organizations. This is changing as the price of electricity is steadily increasing and demand is outpacing the supply of electricity G&T capabilities on both local and global bases. As application server utilization and energy efficiency for powering and cooling these IT resources improve, the focus will expand to include data storage and networking equipment.

A reliable supply of electricity is becoming more difficult to guarantee, because of finite G&T capacity and rising fuel costs. Added to this is increasing demand as a result of proliferating data footprints, more and denser servers, storage, and networks, along with limited floor space, backup power, and cooling capacity. As IT data centers address power, cooling, and floor space challenges with improved energy efficiency and effectiveness, three main benefits will be realized: helping the environment, reducing power and cooling costs, and enabling sustained application growth to support evolving business information needs.

Initially, power and cooling issues are being focused on in larger environments because of their size and scale of energy consumption; however, all environments should be sensitive to energy consumption moving forward. The following examples vary by location, applications, IT equipment footprint, power consumption, budgets, and other factors. For example, in Figure 1.3, the amount of energy required to cool and power IT equipment is shown along with the relative increase reflecting faster, more powerful, and denser equipment. In Figure 1.3, to the right of the graph is shown an area where PCFE resources are constrained, inhibiting growth or causing

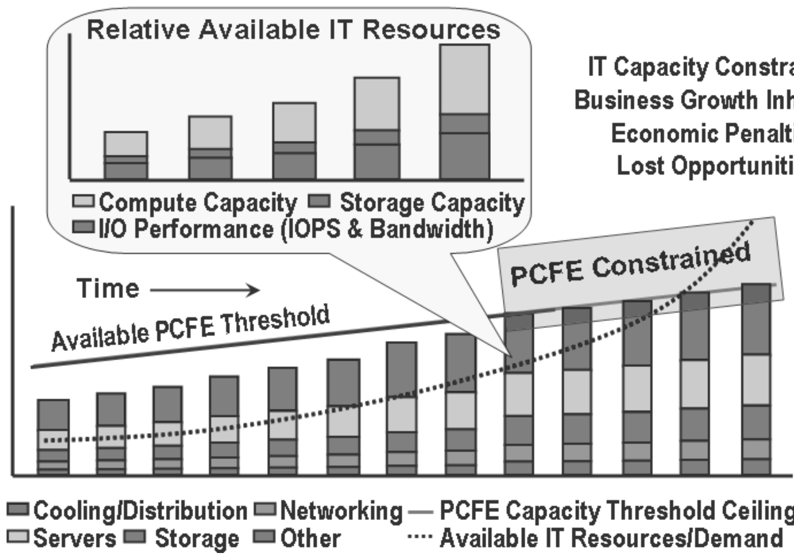

Figure 1.3 IT Resource Growth Constrained by PCFE Issues

increased costs to offset higher energy costs or to pay ETS-related fees, if applicable. Note in Figure 1.3 that, over time, IT equipment is becoming more efficient; however, the sheer density to support increasing demands for IT resources is putting a squeeze on available PCFE resource footprints.

In Figure 1.4, an example is shown with improvements in how energy is used, including deployment of more efficient servers, storage, and networking equipment capable of processing more information faster and housing larger amounts of data. The result of doing more work per watt of energy and storing more data in a given footprint per amount of energy used is that more PCFE resources are made available. The available PCFE footprint enables organizations either to reduce costs and their associated environmental footprint or to sustain business growth while enabling some PCFE resources to be used to transition from older, less efficient technology to newer, more energy-efficient technologies. Additional benefits can be achieved by combining newer technologies with improved data and storage management tools and best practices to further maximize PCFE resources.

1.5.2 EHS and Recycling: The Other Green Focus

Another important facet or face of green is EHS and recycling activities. Recycling and health and safety programs are hardly new, having been

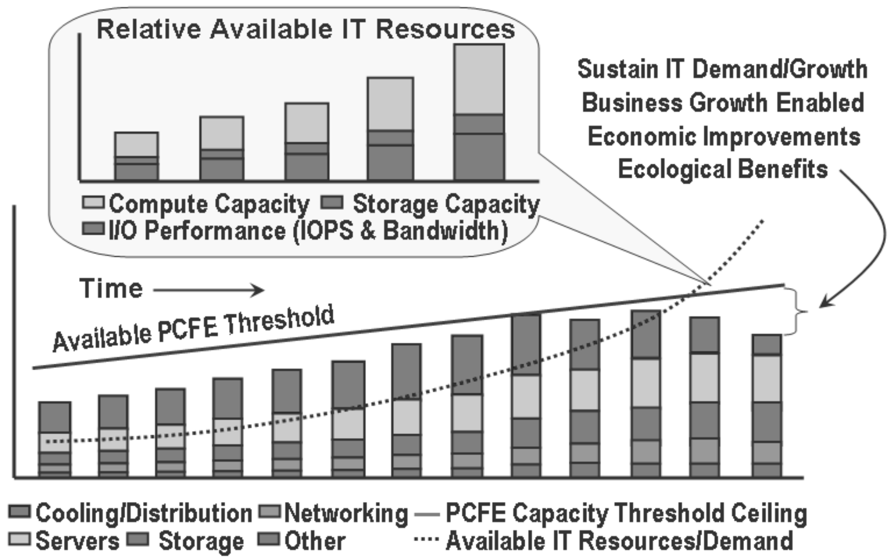

Figure 1.4 Sustaining Business and IT Growth by Maximizing PCFE Resources

around, in some cases, for a few decades. In fact, there are more existing regulations and legislation pertaining to EHS, recycling, disposition, and removal of hazardous substances on a global basis than there are to emissions and carbon footprints. For example, as of this writing, the U.S. Senate is beginning debate on climate change and emissions, while the EU and UK, along with other countries, have ETS programs in place.

The United States does have the Clean Air Act, dating back to the late 1960s and early 1970s, which dictates how certain pollutants are to be reduced, contained, and eliminated. Another example is various material handling standards and regulations, including for **removal of hazardous substances (RoHS)** such as bromine, chlorine, mercury, and lead from IT equipment, which vary with different country implementations. Other examples include politics and regulations around waste recycling as well as reduction and reuse of water or other natural resources in an environmentally friendly manner.

1.5.3 Establishing a Green PCFE Strategy

Do you have a PCFE or green strategy, and, if so, what drivers or issues does it address? If you do not yet have a PCFE strategy or are in the process of

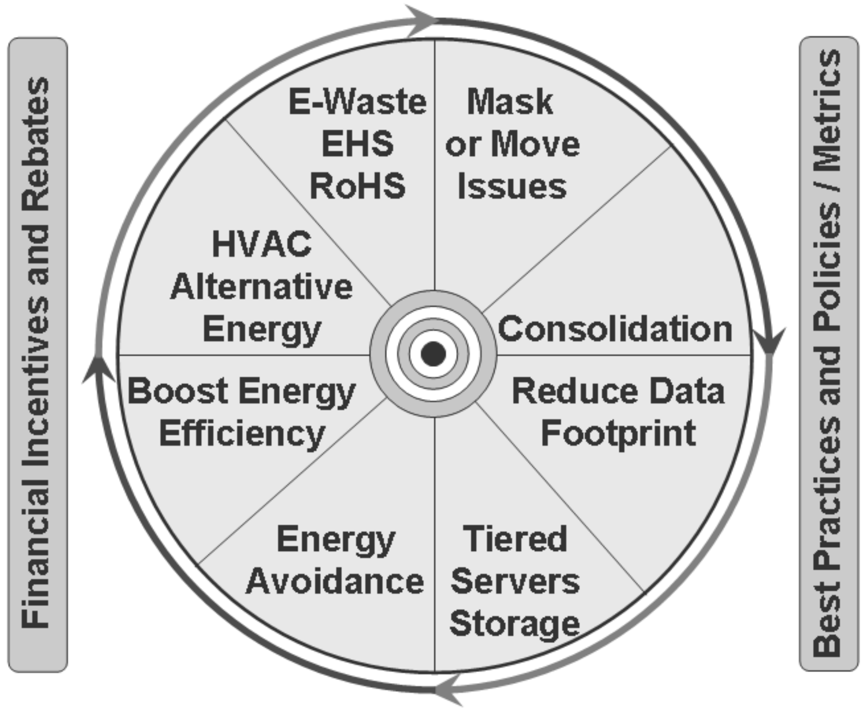

Figure 1.5 Techniques, Best Practices, and Technologies to Address PCFE Issues

creating one, some initial steps include identifying the many different issues. Different issues have varying impacts and scope, depending on specific plan points or requirements along with several alternatives for addressing on a near-term tactical and longer-term strategic basis. Several approaches are shown in Figure 1.5.

Figure 1.5 shows what I refer to as the PCFE wheel of opportunity. The various tenets can be used separately or in combination to address near-term tactical or long-term strategic goals. The basic premise of the PCFE wheel is to improve energy efficiency, by doing more with less, and/or boosting productivity and service levels to maximize IT operating and capital yields. For example, by maximizing energy efficiency, more work can be done with highly energy-efficient servers and storage that process more transactions, IOPS (input/output operations per second), or bandwidth per watt of energy.

Another possibility is consolidation. Underutilized servers and storage that lend themselves to consolidation can be aggregated to free servers for

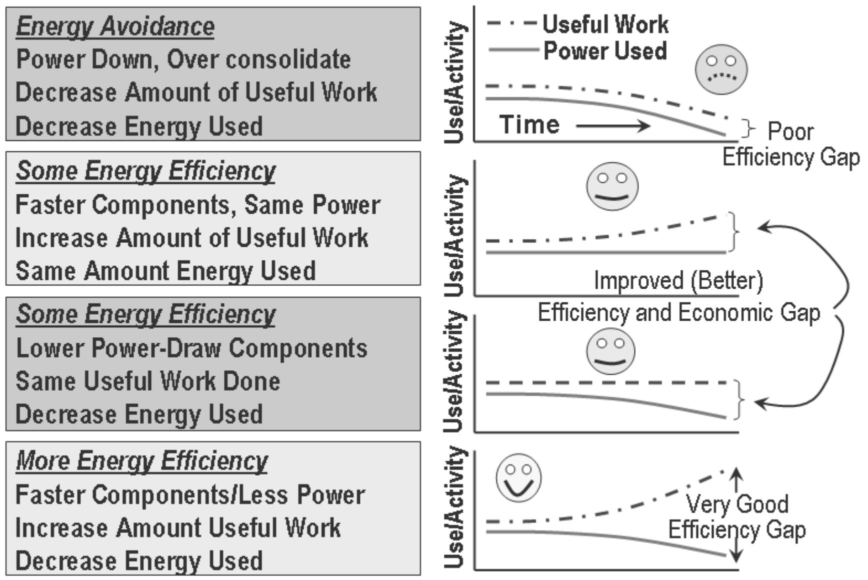

Figure 1.6 The Many Faces of Energy Efficiency

growth or to save energy. The end result is that, by achieving energy efficiency, IT costs may be lowered or, more likely, IT spending, including for electrical power, can be maximized to sustain business and economic growth in an environmentally friendly manner.

Consolidation has been a popular approach to address energy consumption; however, caution should be exercised, particularly with primary external storage. Over consolidation to drive capacity utilization can result in negative impacts on performance.

One point to remember is that in the typical IT data center, depending on configuration, application workload, and **service-level agreements (SLAs),** among other factors, only a small percentage of the overall server, storage, and networking resources will lend themselves to consolidation. Applications that need more processing or server performance capacity, storage, or IT resources beyond what a single device can provide typically are not candidates for consolidation. Another example is situations where different customers, clients, departments, or groups of users need to be isolated for security, financial, political, or other reasons. Servers or storage systems that can only be configured to use a certain amount of resources to meet performance response-time SLAs also are not candidates for consolidation.

Estimates range from as low as 5% to as high as 30% of servers that can be safely consolidated without sacrificing performance or negatively affecting service levels. Estimates on storage utilization vary even more, given the multiples ways storage can be configured and data stored to achieve performance or support operational functions. Not surprisingly, vendors of storage utilization improvement technology, including consolidation virtualization technology or storage resource management and capacity planning software, will talk about storage being only 15-30% allocated and used, on average. On the other hand, finding and talking to IT organizations that operate their open systems storage beyond 50-75% is not uncommon.

Figure 1.6 shows the many aspect of energy efficiency in general terms, with a major emphasis on maximizing available electrical power, improving energy efficiency, and doing more with less to contain electrical power-related emissions. In later chapters, various approaches, techniques, and technologies will be looked at from facilities, server, and storage and networking perspectives to address PCFE issues, including situations where consolidation is not an option.

Given the reliance on available electrical energy to both power and cool IT equipment and the emissions that are a by-product of generating elec-

Table 1.1 Energy Efficiency Scenarios

Energy Scenario	Description and Usage
Energy avoidance	Avoid or decrease the amount of work or activity to be done to reduce energy usage. On the surface, it is appealing to simply turn things off and avoid using energy. For some items, such as lights or video monitors or personal computers, this is a good practice. However, not all IT resources lend themselves to being turned off, as they need to remain powered on to perform work when and where needed.
Do the same work with less energy	Reduce energy usage, performing the same amount of work or storing the same amount of data per unit of energy used with no productivity improvement. This can be a stepping stone to doing more with less.

Table 1.1 Energy Efficiency Scenarios (continued)

Do more work with existing energy	Fit into an existing available energy footprint while doing more useful work or storing more data to improve efficiency. Although energy usage does not decline, energy efficiency is achieved by boosting the amount of work or activity performed for a given amount of energy used.
Do more work with less energy	Reduce energy consumption by boosting productivity and energy efficiency, doing more work, storing more information in a given footprint, using less energy and related cooling. An analogy is to improve miles per gallon for a distance traveled to boost energy efficiency for active work.

tricity, energy is a common area of green focus for many organizations. Improving energy usage or boosting energy efficiency can take on different meanings, as shown in Figure 1.6.

In Figure 1.6 are shown four basic approaches (in addition to doing nothing) to energy efficiency. One approach is to avoid energy usage, similar to following a rationing model, but this approach will affect the amount of work that can be accomplished. Another approach is to do more work using the same amount of energy, boosting energy efficiency, or the complement—do the same work using less energy. Both of these approaches, expanded on in Table 1.1, improve the energy efficiency gap. The energy efficiency gap is the difference between the amount of work accomplished or information stored in a given footprint and the energy consumed. In other words, the bigger the energy efficiency gap, the better, as seen in the fourth scenario, doing more work or storing more information in a smaller footprint using less energy.

Avoiding energy usage by turning off devices when they are not needed is an intuitive approach to reducing energy usage. For example, turning off or enabling intelligent power management for monitors or desktop servers should be as automatic as turning off overhead lights when they are not needed. On the other hand, turning off larger and mission-critical servers and associated active storage systems can have a negative impact on application availability and performance. Consequently, avoiding power usage is not typically a binary on/off solution for most data center environments. Instead, selectively powering down after analyzing application interdependences and associated business impacts or benefits should be pursued.

1.6 Summary

There are real things that can be done today that can be effective toward achieving a balance of performance, availability, capacity, and energy effectiveness to meet particular application and service needs. Sustaining for economic and ecological purposes can be achieved by balancing performance, availability, capacity, and energy to applicable application service-level and physical floor space constraints along with intelligent power management. Energy economics should be considered as much a strategic resource part of IT data centers as are servers, storage, networks, software, and personnel.

The IT industry is shifting from the first wave of awareness and green hype to the second wave of delivering and adopting more efficient and effective solutions. However, as parts of the industry shift toward closing the green gap, stragglers and late-comers will continue to message and play to the first wave themes, resulting in some disconnect for the foreseeable future. Meanwhile, a third wave, addressing future and emerging technologies, will continue to evolve, adding to the confusion of what can be done today as opposed to what might be done in the future.

The bottom line is that without electrical power, IT data centers come to a halt. Rising fuel prices, strained generating and transmission facilities for electrical power, and a growing awareness of environmental issues are forcing businesses to look at PCFE issues. IT data centers to support and sustain business growth, including storing and processing more data, need to leverage energy efficiency as a means of addressing PCFE issues. By adopting effective solutions, economic value can be achieved with positive ecological results while sustaining business growth.

Depending on the PCFE-related challenges being faced, there are several general approaches that can be adopted individually or in combination as part of a green initiative to improve how a business is operated and its goods or services delivered to customers.

General action items include:

- Learn about and comply with relevant environmental health and safety regulations.
- Participate in recycling programs, including safe disposal of e-waste.

- Reduce greenhouse gases, CO_2, NO_2, water vapor, and other emissions.
- In lieu of energy-efficient improvements, buy emissions offset credits for compliance.
- Comply with existing and emerging emissions tax schemes legislation and clean air acts.
- Increase awareness of energy and IT productivity and shift toward an energy-efficient model.
- Improve energy efficiency while leveraging renewable or green energy sources.
- Mask or move PCFE by buying emissions offsets, outsourcing, or relocating IT facilities.
- Identify differences between energy avoidance and efficiency to boost productivity.
- Archive inactive data; delete data no longer needed for compliance or other uses.