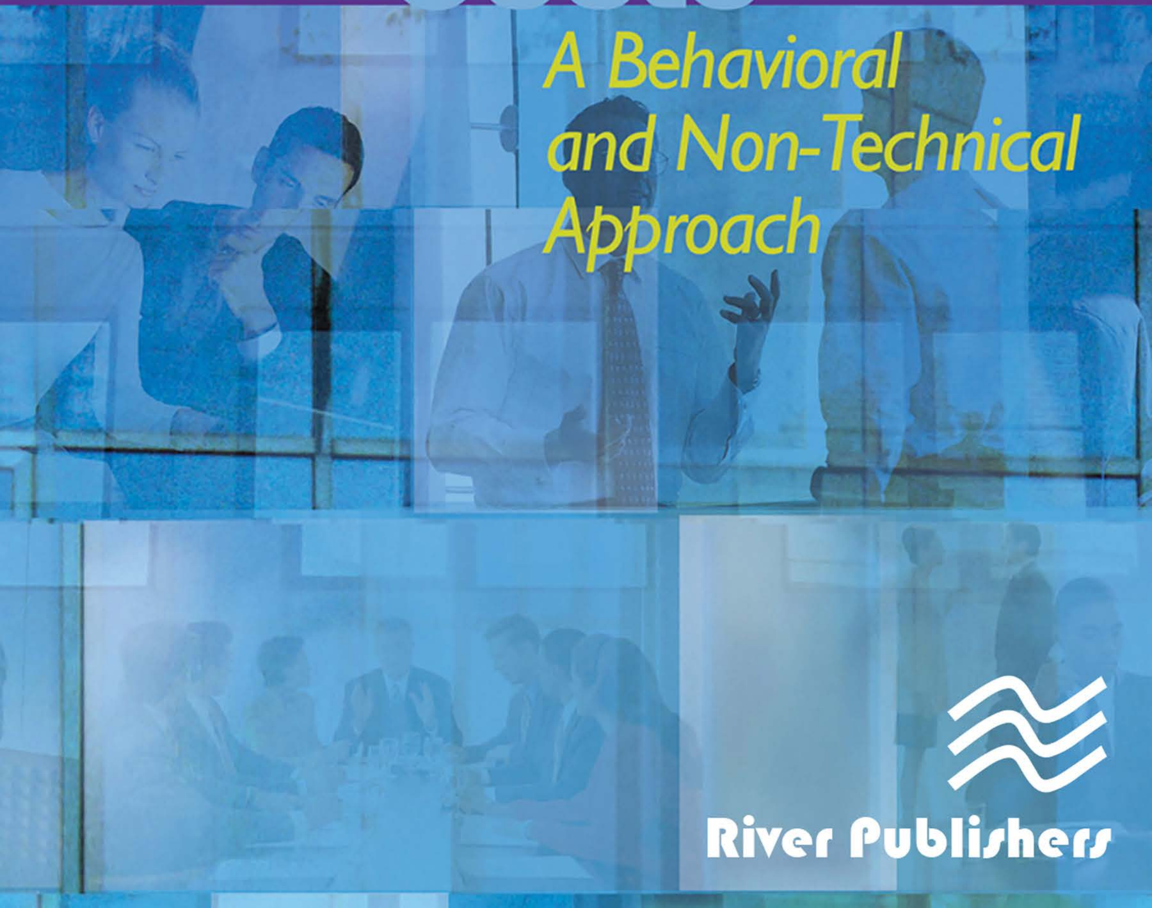
John Eggink

Managing Energy Costs

A Behavioral and Non-Technical Approach



River Publishers

Managing Energy Costs: A Behavioral and Non-Technical Approach

Taylor & Francis
Taylor & Francis Group
http://taylorandfrancis.com

Managing Energy Costs: A Behavioral and Non-Technical Approach

John Eggink

River Publishers

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

Published 2020 by River Publishers
River Publishers
Alsbjergvej 10, 9260 Gistrup, Denmark
www.riverpublishers.com

Distributed exclusively by Routledge
4 Park Square, Milton Park, Abingdon, Oxon OX14 4RN
605 Third Avenue, New York, NY 10017, USA

Library of Congress Cataloging-in-Publication Data

Eggink, John, 1959-
Managing energy costs : a behavioral and non-technical approach / John Eggink.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-8493-8201-7 (print) -- ISBN 978-8-7702-2251-8 (electronic)
1. Energy conservation. 2. Energy consumption. 3. Power resources--Cost control. 4. Adjustment (Psychology) I. Title.
TJ163.3.E37 2006
658.2'6--dc22
2006041283

Managing energy costs : a behavioral and non-technical approach / John Eggink.
First published by Fairmont Press in 2007.

Routledge is an imprint of the Taylor & Francis Group, an informa business

0-88173-544-2 (The Fairmont Press, Inc.)
978-0-8493-8201-7 (print)
978-8-7702-2251-8 (online)
978-1-0031-5122-7 (ebook master)

Contents

Acknowledgements

Much of the research sited in this book comes from government-sponsored programs. Material from the U.S. Department of Energy, the U.S. Environmental Protection Agency, Carbon Trust (funded by the U.K. government), the Canadian government's Department of Natural Resources, the State of California Flex Your Power program, and Lawrence Berkley National Laboratory contributed heavily to this book. Special thanks should also go to George Caraghiaur, Paul Gateo, Ted Klee, Philippe Delorme, Rick Stetler, Mark Feasel, William Rutter, Linda Eggink, Tatjana Grzenia-Eggink, and Cliff Eggink for numerous suggestions, input or motivation. Of course, none of this would have been possible without the unconditional support of my wife, Danielle, and our two daughters, Ellie and Maggie.

Introduction

…if you don't turn out the light, he takes the lights out of the ceiling.

—Maria Shriver discussing Arnold Schwarzenegger's home energy policy with Oprah

Have you ever heard the phrases "Turn off the lights" and "Shut the door?" Slogans like those echoed throughout my childhood. Later in life, as a member of the workforce, I was amazed that I could leave lights and equipment on without hearing about my wastefulness. Was this an implicit directive that waste was okay? Surely not, as one company I worked for rationed pencils. Yet, many energy-consuming devices were on needlessly. How could this be? Why was electrical waste different, not subject to the same cost controls and oversight as other items? At some companies, it appeared that electrical waste was almost encouraged, squandering energy was a sign of success; more usage was deemed better, and somehow reassuring.

This unchecked electrical waste seemed odd to me; so I probed deeper, questioning the status quo. The initial answers were surprising, ranging from pure apathy to myths, such that it is cheaper to leave lights on than to turn them off. I wondered, were these myths true? What did this waste cost? Were we talking a few cents or millions of dollars?

Having an engineering degree, I knew I could tackle any technical issues. Researching this topic became a hobby, or perhaps a quest. I interviewed energy managers, engineers, and executives. I spent many nights and weekends at libraries digging up what little research existed. Technical journals had largely overlooked the role of human behavior in energy usage. Thus, it took many years to develop a comprehensive understanding of the behavioral aspects of energy waste.

I found that "leaving devices on unnecessarily" was a widespread, pervasive, and acknowledged problem costing businesses billions of dollars each year. Most organizations fail to adopt simple low cost, or no cost, energy saving activities. Roughly 15 percent, or more, of an electric bill can be attributable to this oversight. This happens in all types of businesses: production plants that remain partially powered-up over weekends, and offices that keep computers on all night needlessly. These same businesses that measure chemical usage to the drop, track metal shavings to the ounce, and count pencils do not effectively manage the human component of energy management. On the other hand, companies that do address the behavioral aspects of energy consumption reap substantial benefits. IBM, for example, estimates that it saved $17.8 million one year by encouraging employees to turn off equipment after completing tasks and to moderate their use of lighting.[1] Verizon spent less than $5,000 training employees to save energy and reduced its California electric bill by $750,000.[2]

Many companies save hundreds of thousands of dollars on their monthly electric bills, simply through effective employee training and workforce management techniques. Typically, this methodology is called an energy awareness program. The initial goal of the program is to increase an organization's energy IQ, or awareness of energy consumption, its cost and environmental consequences, and to make everyone accountable for energy consumption. The training encourages personnel to turn off devices, and to look for other opportunities to reduce energy costs, such as reporting equipment or maintenance issues, rescheduling loads, negotiating better tariffs, and a host of other low-cost or no-cost actions that can substantially reduce energy costs. Our individual tendency to leave devices energized long after we are through using them can be significantly reduced through effective management and training.

Becoming "energy aware" and sufficiently knowledgeable about electrical energy consumption does not require a lot of time. Everyone in an organization can read this book quickly, in a few hours or less, and gain common understanding of behavioral energy issues. This minor time investment can result in substantial energy savings. Energy awareness programs include proven, repeatable, and affordable measures that reduce energy expenses. Any organization that truly wants or needs to reduce energy costs or reduce dangerous emissions can do so with an energy awareness program. The cost, thereof, is typically low. The investment payback period is short, usually within the same fiscal year.

Ideally, a senior manager gave you this book to solicit your support in reducing energy. If not, please pass it "up" to an executive. Managers are hard pressed for time, so don't be discouraged if they don't immediately jump on the bandwagon. In the meantime, if you want to reduce energy expenses, start a grass roots movement in your sphere of influence.

References

1. John Douglas, "The Energy Efficient Office," *Electric Power Research Institute EPRI Journal*, July/August 1994, P. 16.
2. California Flex Your Power Initiative, *Business Guide 3: Target Business Employees for Energy Conservation in the Workplace,* p 9 http://www.fypower.org/pdf/BPG_Biz3_Target_Employ.pdf (June 22, 2006).

Section I

Linking Behavior and Energy Consumption

Chapter 1

Unique Characteristics of Electricity that Increase Energy Costs

Verizon's employee awareness efforts cost less than $5,000 to implement—but yielded savings of $750,000 and 10 million kWh in California alone.

—California Flex Your Power Program

For all the corporate urging to cut costs however possible, businesses continue to waste energy at an amazing rate. Some of this waste is attributable to the unique physical qualities of electricity. For example, our inability to visualize the flow of electrical energy, or our inability to stockpile and store electrical energy are unusual traits for a commodity. These two attributes alone greatly differentiate electrical energy from most other commodities. These unique qualities govern the pricing, procurement, delivery, and consumption of electrical energy, and influence our propensity to waste electrical energy.

Businesses that have a thorough awareness of the key distinctions between electrical energy and other commonly used commodities are better prepared to reduce energy costs. We will now examine some "cost increasing" attributes of electricity. This is a necessary and painless step towards reducing energy expenses through energy awareness.

ATTRIBUTE #1: ELECTRICITY IS INVISIBLE

Businesses typically measure material waste. We can easily see the pile of scrap or count the number of rejected parts. We can see and hear a running water faucet. Whether it is in gallons or number of pieces, we can visually quantify waste, not so with electricity; therein, lies one problem.

Other than the occasional lightning strike or spark, we cannot see electricity. This invisible characteristic makes it easier to waste electrical energy. For example, if we tip over a carton of milk, we can see the milk pour out. Since we don't want a bigger mess, we usually grab the carton and stop the spill. That's human nature. We can see the puddle, peer in and examine the remaining amount of milk. We can visualize the loss. Because electrical flow is invisible, there is no mess to clean up, no obvious way to visualize the loss, and no reflex to stop the spill.

Consequently, depending on the size of the facility, there may be hundreds or perhaps thousands of electrical "leaks." That is to say, there are many devices needlessly consuming energy. They may be small devices such as desktop computers, or larger devices such as whole building air conditioning units. The point is, unlike spilt milk, we can't naturally see the accumulated energy lost.

Fortunately, we can measure the amount of energy consumed, the amount of money paid for it, and the emissions left behind. Disseminating this energy information is an excellent way to counteract the invisible nature of electrical energy. A good example of this comes from Harvard University. While entering the dinning hall at the Spangler Center I could not help but notice a poster board resting on a tripod. I have duplicated this poster at the top of the following page.

This low-cost poster accomplishes several things: (1) it shows a correlation between energy conservation and financial savings; (2) it appeals to environmentally concerned individuals by emphasizing the environmental aspects of energy conservation; (3) it equates invisible energy to tangible items such as barrels of oil

If HBS [Harvard Business School] can achieve a 3% total energy reduction in one month it would save $8,967.93 and offset 105,052.89 pounds of harmful CO_2. This amount of reduction is equivalent to saving 111 barrels of oil or 5,427 gallons of gasoline.

Facility	Savings
Dillon	15%
Loeb	15%
Cotting	10%

1st Annual Energy Competition 10, July, 2006 – 10, August, 2006
HBS GREEN TEAM (and contact information)

and gallons of gas; (4) it creates energy awareness among the students, staff, and guests; (5) it communicates that saving energy is important and results are monitored and measured; (6) it serves as the scoreboard for an energy saving competition between several campus buildings. All the contestants receive feedback on their efforts. The winners, tied at 15% savings, are recognized for their accomplishments. (I did omit the names of five buildings tied for last place.) What's more, the "percentage based" competitive measurements utilized by Harvard are, in this case, advantageous. It is easier to visualize reducing energy consumption by 1%, than reducing a fixed (absolute) metric such as $3,000 dollars or 300 kilowatt-hours. Individuals are more motivated by relative values than absolutes.[1] Please note, the terms "savings," "offset" and "avoided costs" are often interchangeable when discussing energy conservation topics.

Another way of making energy more visible is to graph the relevant energy metrics. Graphs can provide a "picture" of the energy usage. Our eyes are good at spotting patterns and quickly identify anomalies, or opportunities to save energy. I can't emphasis enough the importance of properly graphing interval energy data versus just utilizing rows of figures. It is impractical to study thousands, or often millions of lines of data. However, graphically

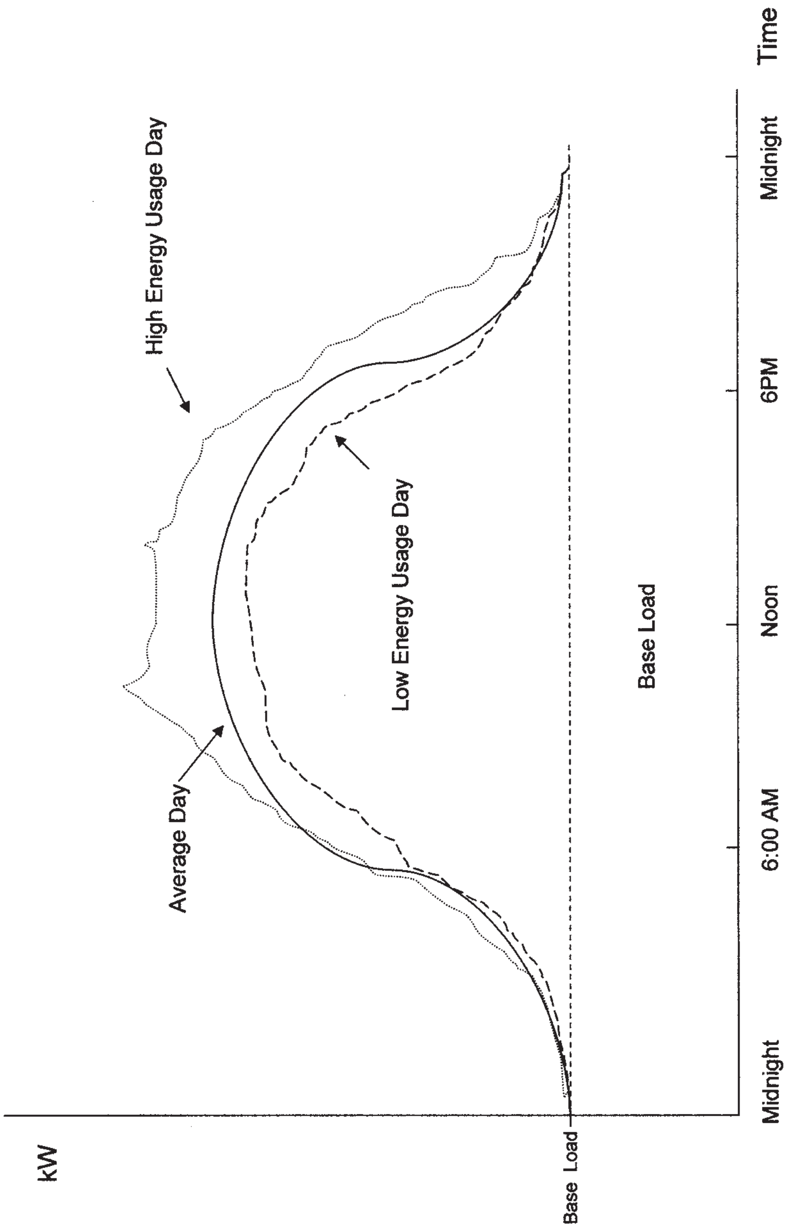


Figure 1.1: Daily View of Energy Consumption.

displaying the data enables the eye to spot deviations quickly, which turns the data into useful information.

Figure 1.1 shows a typical office building "load profile." A load profile is a graph of the variation of electrical consumption versus time. The vertical, or y-axis, represents the amount of electrical power consumed. Since the graph's purpose is to show the consumption pattern the y-axis does not indicate the actual numerical amount. The middle line represents the average electrical load. The outer lines represent the hypothetical minimum and maximum values. Weather, building occupancy, manufacturing output, or energy saving activities can significantly affect the load profile.

Figure 1.2 shows a weekly load profile. We can see the energy consumption increase throughout the day and drop every night. Notice that on Wednesday night the power use did not drop as expected. There could be several reasons for this. One possibility is energy usage from a special event, such as a concert or dinner banquet. Another possibility is the night cleaning crew failed to turn off equipment and lights. Another concern is the high weekend energy use. Each building will be different, hence the need for human intervention to analyze the graphs.

Figure 1.3 shows a scatter plot of energy usage. Each box in the graph represents an individual day. Moving from a box horizontally to the y-axis shows the amount of energy used that day and the x-axis is shows the outside air temperature. The x-axis can be any energy influencing factor, such as the production rate in a manufacturing facility. In an office building, the outside air temperature can greatly affect energy consumption.

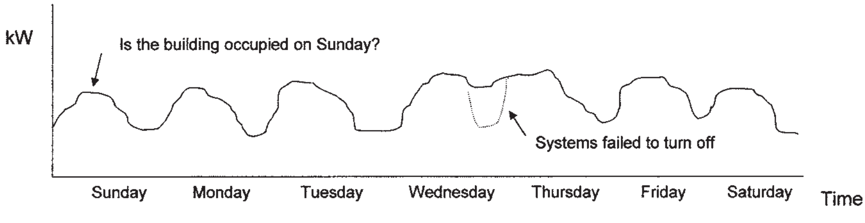


Figure 1.2: Weekly View of Energy Consumption.

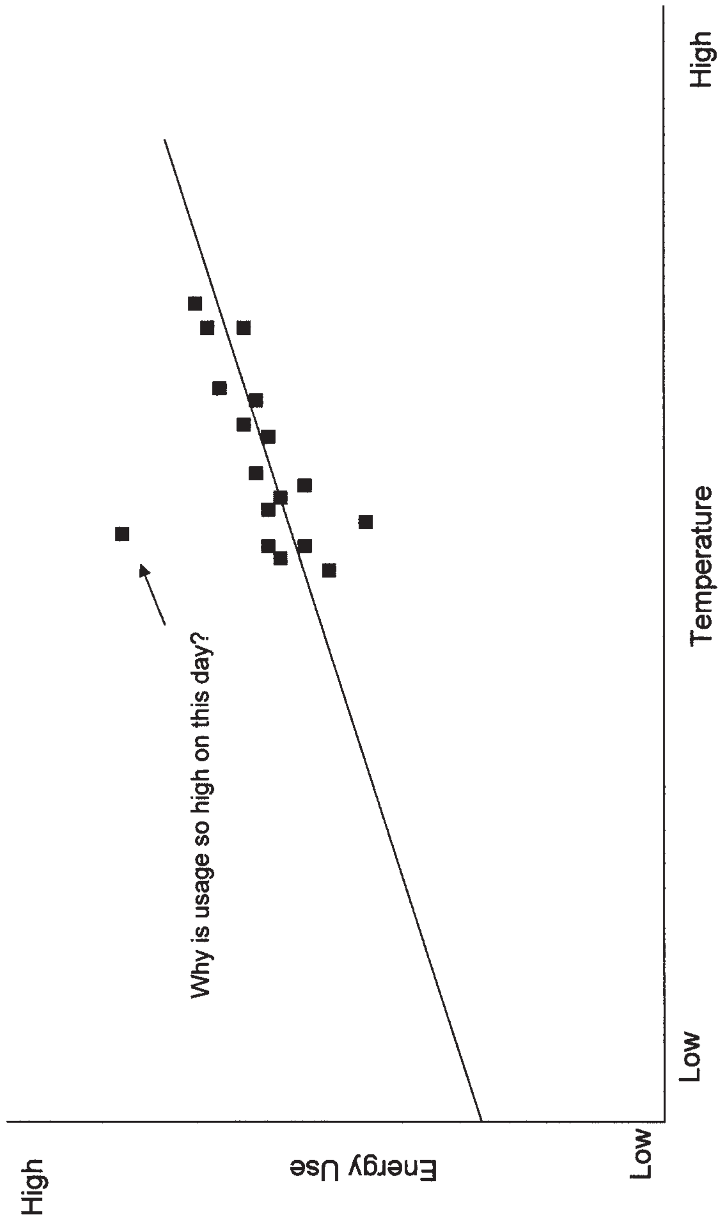


Figure 1.3: Departure from Expected Energy Usage.

In a manufacturing facility, it is often the number of widgets, or type of widgets produced that influence energy consumption. The solid line is the forecasted load. As expected, the energy use increases with the temperature, however we can easily see there is one day that greatly exceeds the forecasted energy usage. A graph like this allows any non-technical person to spot patterns in energy consumption quickly and easily. Graphs like these make the energy usage visible and understandable. It is also important to generate the graphs close in time to the actual usage. Rapid feedback is critical for efficient learning and quick resolution of high-energy events.

ATTRIBUTE #2 ELECTRICAL ENERGY IS THE ONLY PRODUCT CONSUMED THE INSTANT IT IS MADE

The courts are split on whether electricity is considered a product (good) or a service. The answer depends, in part, on where you live, and can be a decisive factor in litigation. Regardless of the legal definition, electrical energy is consumed the instant it is generated. Let's think about this for a second. Virtually all other products we consume can be manufactured in advance and counted as inventory. The electrical energy we use at work and home arrives at near the speed of light from a utility generator.

One consequence of not being able to effectively store electrical energy, or keep any electricity inventory, is that utilities must always have the capacity to manufacture the maximum required electrical energy that customers demand.[2] If the consumers demand for electricity is greater than utilities can supply, it creates tremendous problems and can cause the entire grid to collapse. One analogy is perhaps that of riding a bike. It is easy to balance and stay up when we are moving quickly, but as the bike slows, we become unstable. If the utility generators cannot maintain their desired speed, corresponding voltage, and frequency, the system will crash. To avoid a catastrophic failure, utilities will turn off electricity to small geographical areas to keep the generators running. This controlled outage, often called a rolling blackout, is a desperate maneuver designed to keep the power grid from collapsing. Power outages can have tragic consequences and even result in loss of life, as traffic signals and other essential equipment fail.

Building the necessary power plants and transmission lines to handle this maximum electricity use is an expensive endeavor, especially, if it is only needed a few short times during the year, usually on the hottest summer days, when air conditioning use is at its peak. So ideally, utilities try to encourage their customers not to consume electrical energy during the peak usage periods in an attempt to reduce the maximum demand for electrical power. How does the utility do this? Simple, by adding additional charges to make electricity more expensive during the peak time of day when the electrical energy consumption at its highest. The higher prices discourage electrical energy consumption during peak times, or conversely, the higher prices help finance the additional infrastructure.

The maximum demand period varies by region, but generally falls between noon and 7:00 P.M. Depending on the particular utility tariff, energy costs can be substantially higher during certain peak times. We should especially watch our usage when rates are the highest, typically from lunchtime though the early evening when the actual peak demands typically occur. This can be as simple as turning off computers and lights when we leave for lunch or home. Industries can sometimes reduce electrical bills by staggering lunches. For example, if warehouse operators recharge forklift batteries during their lunch break, the simultaneous charging of all the forklifts can create a peak demand and larger than necessary electric bills. Staggering the forklift operator's lunch schedules reduces the instantaneous electrical power and lowers the electric bill.

One extremely positive ramification of immediate consumption is that conservation results are instantaneous. If we get up now and turn off one light, one copy machine, one assembly line, or any appliance, instantly the utility generator transfers less electrical energy, and the electric bill is reduced.

ATTRIBUTE #3: ENERGY MANAGEMENT IS DIFFERENT FROM ENERGY CONSERVATION

At this point, you may be thinking that shifting energy use to different times of day is not really reducing energy consumption. This is counter-intuitive to some people, but an energy management initiative could actually increase the total amount of energy consumed, but still reduce the total price paid for energy. Cost reduction may be achieved by shifting loads to times when energy is cheaper, thereby receiving smaller utility bills, and yet use the same or even more energy.

Energy managers may negotiate with energy suppliers and select the cheapest utility tariffs. The energy manager may contact the water company to request that evaporated cooling tower water (water used by the cooling process and not returned to the sewer system) not be subject to sewer charges, thereby reducing the utility bill. Sounds simple, but many organizations do not bother to do this. Managing the cost and reliability of energy is just as important as managing energy consumption.

ATTRIBUTE #4: ELECTRICAL TERMINOLOGY IS COMPLICATED

The technical aspects of electricity can bore and confuse people. Aside from being intangible, electrical units are often convoluted. If a gasoline station sold gas the same way electric utilities sold electricity, gas stations would charge us for "kilogallons-pumped-per-second per hour" in lieu of gallons.[3] It does not need to be that hard.

Executives, plant or facility managers, and engineering staff should know three main billing terms. They are kilowatt-hour, watt, and power factor. Simple definitions are as follows:

- Kilowatt-hour (kWh)—A kilowatt-hour is the basic unit used to measure and sell electrical energy. It is often called energy consumption, or sometimes just electrical energy. Think of a kWh as you would an odometer on a car; it is a cumulative sum. The k in kWh represents the number 1,000.

  The kilowatt-hour charge can be broken down into kilowatt-hours consumed by time period. For example, the utility may charge one rate for kilowatt-hours consumed "on-peak" (for example, 10:00 A.M to 7:00 P.M weekdays and holidays) and a different rate for kilowatt-hours consumed "off-peak" (all other hours). This is called "time-of-use" (TOU) billing.

- Watt (W)—The other frequently used term is the watt. It is a measure of energy flow often referred to as power, active power, demand, kW (1,000W), peak demand, kW demand, or megawatt (1,000,000 W). One reason utility companies call this demand is that customers just take it. Few people call and say, "Can I plug in a few more devices?" We expect a limitless supply to be available. Think of watts as the vehicle equivalent of a speedometer; it is an instantaneous reading. It represents the amount of electrical energy consumed at any given moment.

  Utilities often add an additional charge for kW demand. In this case, kW demand is an average value of watts, typically averaged over 15 to 30 minutes. There are variations on how utilities calculate the average demand, but the same principles hold. If we go back to our speedometer analogy, remember that kW is an instantaneous value equivalent to our speed, say 60 miles an hour. If you where to drive for one hour your speed may vary, it may be 0 miles an hour for a few minutes then rise to 70 miles an hour for a few minutes. To calculate the average speed, you simply take the number of miles you drove and divide by the length of time you drove. So, if you drove 59 miles in one hour you averaged 59 miles an hour. This is the equivalent of what utilities do. They take the kWh used over an amount of time and divide by the same time period and get an average kW (the "time component" cancels out on the numerator and denominator). For example, 2,000 kWh used in 15 minutes (1/4 hour or .25 hours) yields a demand of 8,000 kW (2,000kWh/.25h = 8,000 kW). The highest demand reading in a billing period becomes the "peak" demand.

Utilities bill the "peak demand" to recoup the costs of building and supporting the infrastructure required to deliver the maximum kW needed, even if only used once or twice a year. In some parts of the country, demand charges may account for roughly half the electric bill, so understanding how fast a facility uses energy may be just as important as knowing how much energy is consumed.

Usually, the demand charge is reset each month. That is, each month is billed for the peak demand that occurred in the month. There is a costly variation on the demand penalty called a Ratchet. A ratchet uses the higher of the current peak demand or any past peak demand. With a ratchet tariff in effect, setting a new peak demand level has consequences well into the future.

- Power Factor—Motors and transformers utilize electrical current to create magnetic fields. In addition to the power that actually produces useful work, utilities must also supply the power to create these magnetic fields. Further technical details are beyond the scope of this book, but a simply analogy is the foam in a glass of beer or soda. When pouring the beverage, foam can accumulate in the glass. The foam causes two problems: one, it takes up space in the glass; two, it is an inefficient use of the beverage. Power factor represents the electrical equivalent of foam, which in reality is the energy used to create magnetic fields. Power factor is always a dimensionless number between 0 and 1.

  Many utilities do not charge for poor power factor, but those that do typically start charging additional fees at a power factor of less than 0.95. There are some no cost ways to reduce power factor such as minimizing the operation of lightly loaded or idling motors. If the power factor is still out of tolerance, there are power factor correction devices that can mitigate the problem.

When dealing with a larger audience, rather than use technical terms such as kilowatt-hours or watts, it is sometimes preferable to express energy in simple and easy to understand units such as dollars or percent to goal. These units are often more familiar and tangible. A good example of this comes from "Climate: Making Sense and Making Money:"

> At a large hard-disk drive factory, the cleanroom operator started saving lots of money once the gauge that showed when to change dirty filters was marked not just in green and red zones, but in "cents per drive" and "thousand dollars' profit per year.[4]

Again, when measuring, tracking, or reporting energy usage, it is preferable to express units in terms that are understandable and measurable. Sometimes this requires monetizing the energy usage and discussing it in terms of its financial cost. Sometimes this requires converting the energy units to emissions equivalents, or as a percent to goal, or compared to prior usage. Expressing energy consumption in units of pollution such as carbon dioxide (CO_2), nitrogen oxides (NO_x), or other volatile organic compounds and particulates can be effective in decreasing energy costs. Organizations such as universities or hotels should place extra emphasis on the emission equivalent of energy consumption, such as pounds of carbon dioxide. We will discuss this more in later chapters.

Information should be timely. An electric bill showing abnormally high-energy usage a month ago is not as useful as a daily report that enables immediate cost reduction activity. The main concept is that the metrics need to be relevant, personal, accurate, timely, and easy to understand.

ATTRIBUTE #5: ELECTRICITY IS THE CARRIER OF ENERGY, AND NOT AN ENERGY SOURCE

We often forget that electricity is merely the mechanism used to transport energy. Electricity is a secondary energy carrier and not an energy source. Its availability requires conversion from other energy sources or carriers, mainly from:[5]

- Mechanical power derived from thermal energy, or heat. The heat comes from burning fossil fuels such as coal, natural gas, and petroleum, or in lieu of burning fossil fuels, a nuclear reaction can generate heat.
- Directly harvested mechanical power, such as wind or hydroelectric, in which wind or water turns a generator transferring energy.
- Light (solar radiation) such as solar cells.
- Chemical energy, such as fuel cells, that turn natural gas into electricity.

Sitting in our modern offices, we no longer experience a direct correlation to our dependence with the actual energy sources. We cannot see the fuel that is burning to create the energy used to power our lights and equipment, but it is burning. The majority of electrical power comes from nonrenewable resources such as coal, oil, and natural gas (see Figures 1.4-1.5). In the United States about 50 percent of electrical energy comes from coal. Worldwide, burning coal generates 40 percent of electrical energy.

The fossil fuel burned by the utility to power the unneeded lamp is lost forever. Wasting energy devours excessive amounts of these finite resources. Reconnecting with the reality that electrical energy comes primarily from burning a finite supply of fossil fuels can increase our incentive to conserve.

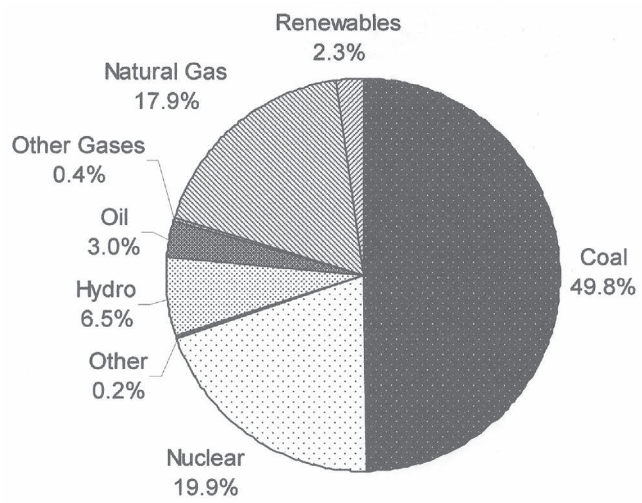


Figure 1.4: United States Electrical Energy Sources. ***Source data from U.S. Energy Informaton Administration (EIA), 2004 data.***

ATTRIBUTE #6: ELECTRICAL ENERGY IS SUPPLIED EFFORTLESSLY

Not long ago, during the winter season, our ancestors had one of two choices. They could build a small fire and sit close to keep warm, or build a large fire and sit further back. Either way the fire provided the necessary heat to keep them alive. There was a direct consequence to building a larger fire; it required considerably more effort to gather the extra wood.

Our world is different. No such obvious choices are required. Utility companies deliver energy straight to our homes and businesses on a continuous basis. We do not have, nor associate, any inconvenience with using energy delivered real-time on demand, nor do we feel any need to ration a resource that seems limitless. The long lag time between usage and receiving the utility bill further robs us of helpful feedback on our energy habits.