solutions

From Shop Floor to Top Floor: Best Business Practices in Energy Efficiency

by

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PEW CENTER ON Global CLIMATE CHANGE

CASE STUDY

IBM Integrated Approaches	
Headquarters:	Armonk, NY
CEO:	Sam Palmisano
Revenues (2008):	$103.6 billion
Energy Costs (2008):	Undisclosed
Energy Savings Target:	4 percent annual savings target in 1996 with a requisite business process to collect and report company wide data. An enterprise-wide software system for data management was implemented in the 1990's. In 2006, the target was modified to 3.5 percent annual conservation savings.
Key Efficiency Strategy Successes:	• 3.5 percent annual energy conservation target surpassed in 2008. Actual savings were 6.1 percent, leading to $32.3 million in savings, and $16.4 million in cost avoidance; • Instituting a global energy reporting and accountability system across 650 facilities; • Implementing global best practices checklists to assess conservation opportunities; • Leveraging internal operations experience and IT expertise to formulate new customer product and service offerings; • Encouraging key suppliers to disclose their greenhouse gas (GHG) inventory, management plans, and any reduction commitments, through the Carbon Disclosure Project's Supply Chain program & Electronics Industry Citizenship Coalition.

Energy Conservation Strategy Overview

Like many companies where well-trained engineers and dedicated managers work to improve productivity and manage costs, IBM responded to the energy crises of the 1970s by trimming energy expenditures through a mix of good housekeeping activities and technology investment. The company set its first energy conservation policy in 1974, focusing on operations at the individual facility level, with initial efforts directed toward simple, low-tech conservation initiatives. Engineers and facility managers took actions to turn off lights and HVAC systems when they were not needed, and tune up energy systems such as steam, compressed air or chiller water systems to improve their efficiency. Capital investments followed, with energy efficiency competing for funds with other projects subject to the company's payback requirements.

But an important shift occurred in the 1990s. Energy at IBM went from a shop-floor issue to a top-floor issue. Growing commitments from governments to address climate change, combined with basic shifts in energy markets, convinced IBM leadership that the global energy use paradigm was beginning to be transformed. Senior executives saw a shift from cheap, abundant energy based on fossil fuel supply technologies, to expensive energy from shrinking fossil fuel sources overlaid by an imperative to reduce carbon dioxide emissions. IBM management recognized that the company had to redouble its efforts to actively manage energy use and to manage risks associated with potential energy supply disruptions, escalating cost, and climate change regulations. In accord with these developments, IBM undertook voluntary commitments to measure, report, and continue to improve its environmental performance, joining initiatives such as the U.S. EPA Climate Leaders program, the Carbon Disclosure Project, and the Chicago Climate Exchange, which require greenhouse gas emission inventories, reports and reduction goals. These commitments, combined with the rise in energy prices in the past decade, placed a new emphasis on collecting, reporting, and acting on energy usage information on a company-wide basis.

In 2006, in an atmosphere of rising energy prices and an increased public policy focus on energy efficiency and climate change around the globe, IBM took its energy conservation strategy to a new level, by expanding a mandatory energy conservation gap analysis (a comparison between an established list of best practices and conditions at each location) and an energy tracking and reporting system to all its facilities around the globe using more than 2,000 megawatt hours (MWH) of energy annually. While the company had set targets in 1996 to implement conservation projects that reduce or avoid energy use equivalent to four percent of the company's annual energy consumption,[1] the addition of the mandatory energy conservation gap analysis and expanded reporting effort made the company's commitment real and measurable across the global organization. Metrics reporting was expanded to include on-line monthly and quarterly reports of location energy use and performance against conservation targets, providing senior executives on-line access to comprehensive energy data.

These changes increased the number of facilities required to report energy use and perform conservation assessments from 500 in 2005 to 650 in 2008. Mobilizing all of the relevant business units and engaging them in the conservation strategy was a significant undertaking. In some cases, the Real Estate and Site Operations (RESO) organization—the organization tasked with the overall mission of energy management within IBM—had to forge new relationships with business unit teams, such as the data center groups, while in other cases, such as the manufacturing sites, existing relationships were expanded. In many instances, business unit teams had no previous experience dealing with energy metrics, so a degree of education was required. Additionally, the 150 locations that

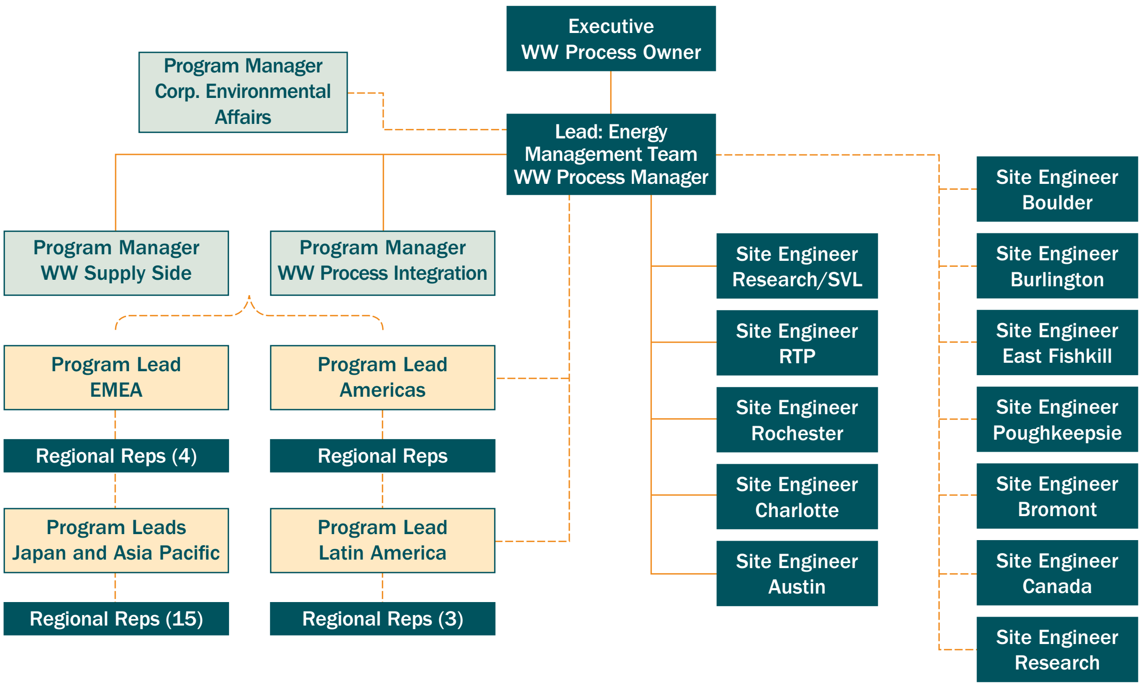
1 IBM's energy conservation target is calculated by summing the annual savings achieved by energy reduction and avoidance projects and dividing that by the total energy use for that calendar year.

had not previously been subjected to a rigorous energy conservation analysis at their facilities needed to expand their technical skills. Further, business units required assurances that conservation technologies and practices would not impact product quality, operational reliability, or production goals.

The corporate energy management team, which focuses on both energy procurement and energy conservation and efficiency, resides in the RESO organization. The team includes representatives from each of the major North American facilities and from designated global regions. Energy issues at smaller locations that use less than 15,000 MWH of energy annually are typically assigned to a regional energy coordinator who works with the location teams to evaluate and implement energy conservation projects. The energy management team also includes energy subject matter expert task groups, focused on lighting, HVAC, controls, etc. This allows the energy team to cut across operating units, and provide expertise across global company operations (see **Figure 1** for an overview of IBM's Corporate Energy Management Team). In the figure, WW stands for worldwide, while SVL and RTP refer to IBM facilities located in Silicon Valley and Research Triangle Park, North Carolina, respectively.

Figure 1

IBM's Corporate Energy **Management Team**



Recreated from image provided courtesy of IBM (2009).

The energy team learned early on that it would need to make some accommodations to get the level of cooperation needed to significantly beef up IBM's energy conservation strategy. For example, the corporate target of conserving energy each year equal to four percent of the company's annual energy use was adjusted down to 3.5 percent, though it was also expanded to cover additional leased spaces. To ensure the corporate level target is met, the four percent energy conservation target has been maintained at the larger facilities that have a greater range of opportunities for conservation savings, driving "overachievement" at these places. These larger locations also received energy use reduction targets, specifically aimed at driving absolute reductions in location energy use, in addition to their conservation targets. Smaller locations were given slightly lower percentage reduction targets and, in some cases, targets are aggregated regionally to allow effort to be focused on the best opportunities. IBM used a variety of means to encourage and sustain active cooperation among some 650 facilities including education, persuasion, technical assistance, program assessments, and competition among sites. Energy team members spent a lot of time one-on-one, in conference calls and emails, and in site visits, helping site operations teams around the world learn the new system.

The energy team has combined its expertise to produce a wealth of operating practices and technology investment opportunities for the energy-intensive facilities. They also translated these findings into standardized best-practice checklists, applicable to IBM's global property portfolio.

While the company's energy savings goals were set for many reasons, actions undertaken to reach the target still needed to make financial sense. When efficiency was a shop-floor issue, companies typically used standard "simple-payback" criteria to screen out projects that took longer than a few years to pay for themselves. In its 21st-century strategy, IBM found it needed to think beyond "simple payback" or other standard measures such as Internal Rate of Return (IRR) as the only financial gauges for efficiency investments. Like many businesses, IBM applies the same financial criteria to its energy efficiency investments as it does to other business investments, typically two to three years payback depending on business conditions. But the energy management team has found that energy conservation projects bring other benefits to the business, such as improved manufacturing productivity, better utilization of assets, the return of "energy capacity"[2] to the business that can be used to generate additional revenue, space use reductions, and other measurable business returns (see text box on the next page for an example of some of energy efficiency's co-benefits experienced by IBM). By working with the business units, the energy

2 Increased energy capacity occurs in situations where energy availability is constrained either by facility system capacity or the capacity of the delivery grid. Implementation of conservation projects frees up energy, making it available for new operations or the growth of existing activities. It can also enable the avoidance of investment in upgraded or expanded facility systems.

Co-Benefits of Energy Efficiency Improvements

Data center energy efficiency improvements can reduce energy use by five to 10 percent within the existing server inventory and application workload. Consolidating workload onto fewer servers and storage systems can further reduce energy use and reduce floor space needs. This freed-up space can then support service sales growth for new and existing accounts. At one IBM data center, this approach freed up 1.5 percent of its floor space for account service growth and avoided IT equipment investment of $2.5 million. The overall savings driven by these additional business benefits make the business case more compelling, providing a stronger justification for implementing these types of projects.

management team can quantify these benefits and improve the investment return to strengthen the business case for the project. Close cooperation with the business units also identifies those projects or energy management/conservation techniques that can be translated into client offerings. As a result, today, efficiency at IBM is linked to a much larger value chain than it was in the earlier days of energy management.

One of energy efficiency's key ties to this larger value chain, and its ability to drive so much change in large organizations, is its pervasiveness. Virtually everyone in an organization has some influence on energy use, be it the light switch in their office, the power management settings on their computer, or the production process or data center they manage. Other environmental issues tend to be limited to fewer people and fewer locations. Hazardous materials, for example, are typically generated in specific production operations, and are handled by specialized staff and contractors. From an Environmental, Health, and Safety or Corporate Responsibility perspective, such issues tend to be more specialized and do not involve all or even most of the organization.

Energy, by contrast, can get lots of people involved. Companies like IBM have found that employee engagement is a key part of their energy strategies. Beyond posting signs reminding people about switching off lights, employee newsletters, and other routine communications, some IBM locations offer $500 rewards for useful energy efficiency suggestions. While such incentives appear to be generating lots of good suggestions, the energy team finds that what really drives people in this process is the innate desire to solve problems, and to make a difference beyond their specific job description. IBM and other companies have been surprised by how resonant the energy conservation message has been throughout the company, improving morale as well as productivity.

The picture that emerges from a look into IBM's energy conservation strategy could be termed "data driving information driving action." As energy use has increased in importance as a business imperative, IBM has improved its data collection and management system from a spreadsheet system used decades ago to an enterprise wide data collection system. The energy conservation team has expanded, from a location-centric focus to a global energy team. And the team has established detailed global energy conservation and efficiency best practices and standards to dictate energy performance at operating locations worldwide. Progress toward the energy savings goals is tracked using a monthly/quarterly/annual reporting process, which goes to senior management, which drives deeper scrutiny and empowers efficiency actions at the facility level. The energy team reports that business unit and division leaders, once they began to see individual facilities' performance in the red and green performance indicator colors, began calling and emailing managers at facilities that had fallen behind to find ways to improve performance. See **Table 1** for a sanitized screen shot of the Business Intelligence @ IBM (BI@IBM) Energy Management reporting system. Red highlights indicate facilities or regions that are lagging on energy performance; green highlights show progress ahead of targets. In **Table 1**, the smaller box at the top represents aggregated totals from several IBM facilities, while the larger box shows energy use data from individual facilities.

IBM's overall Corporate Responsibility efforts provide transparency into the company's environmental performance, with the energy reporting system being a core element of that effort. IBM has reported the company's energy and/or carbon dioxide emissions targets, and its actual performance through the company's annual Environmental Report without interruption since 1990. It emphasizes that saving energy is not just an engineer's job—it is everyone's job. Similar information has also been disclosed through IBM's Corporate Responsibility Report.

Energy Conservation and IBM's Climate Strategy

IBM's energy conservation strategy is the cornerstone of its overall climate strategy, with efficiency and conservation projects providing the majority of the company's direct and indirect CO_2 emissions reductions. Over 80 percent of IBM's energy use results from purchased electricity. The CO_2 emissions associated with this energy use depend on the fuel sources of the generating portfolio of the country or regional electricity grid.

Like many of the other companies studied in this report, IBM does not expect to sell energy efficiency as a tradable commodity in carbon markets. Concerns about double counting have so far precluded these "indirect" emissions reductions from qualifying as carbon credits in legislation establishing greenhouse gas cap-and-trade systems being considered at the federal level.[3] There may, however, be opportunities for IBM to participate in the demand reduction/energy efficiency markets that are being established in some states and countries. Regardless of the applicability of regulatory programs, efficiency continues to justify itself on sound business grounds, while also

3 For a more detailed description of this issue, please see page 11 of the body of the report.

Table 1

IBM's Business Intelligence Energy Management Reporting System

As of Date	10/2009	10/2009	10/2009	10/2009	10/2009
Previous Year YTD Usage Total	NA	NA	NA	NA	NA
Current Year YTD Usage Total	NA	NA	NA	NA	NA
Year to Year PCT Chg Total	-2.0%	-2.0%	-2.0%	-2.0%	-2.0%

Rank Num	Locations	Geographies / IOTs	Countries	Previous Year YTD Usage (MWh)	Current Year YTD Usage (MWh)	Year to Year PCT Change	Avg CY Rate ($/MWh)	YTD $K Impact
1	Location 1	North America IOT	United States	438,512	406,926	-7.2%	$80.13	-$2,531
2	Location 2	North America IOT	United States	376,767	343,814	-8.7%	$85.29	-$2,811
3	Location 3	North America IOT	United States	212,888	193,991	-8.9%	$81.24	-$1,535
4	Location 4	North America IOT	United States	118,050	125,481	6.3%	$56.71	$421
5	Location 5	North America IOT	United States	151,824	148,770	-2.0%	$52.05	-$159
6	Location 6	North America IOT	United States	90,099	83,173	-7.7%	$81.45	-$564
7	Location 7	North America IOT	Canada	113,449	104,042	-8.3%	$41.28	-$388
8	Location 8	Southwest Europe IOT	France	47,704	63,622	33.4%	$71.35	$1,136
9	Location 9	North America IOT	United States	64,357	64,954	0.9%	$83.44	$50
10	Location 10	North America IOT	United States	94,564	87,572	-7.4%	$73.70	-$515
11	Location 11	North America IOT	United States	44,031	42,191	-4.2%	$118.21	-$218
12	Location 12	North America IOT	United States	50,148	49,553	-1.2%	$68.50	-$41
13	Location 13	Northeast Europe IOT	United Kingdom	45,023	42,971	-4.6%	$119.66	-$246
14	Location 14	North America IOT	United States	38,308	37,830	-1.2%	$114.23	-$55
15	Location 15	Latin America GMT	Brazil	45,062	52,163	15.8%	$154.74	$1,099
16	Location 16	North America IOT	United States	44,714	47,107	5.4%	$123.49	$295
17	Location 17	Northeast Europe IOT	United Kingdom	42,061	43,418	3.2%	$113.91	$155
18	Location 18	Northeast Europe IOT	Ireland	25,544	21,271	-16.7%	$113.40	-$485

Recreated from image provided courtesy IBM (2009).

providing the largest and most consistent basis for reducing IBM's GHG emissions inventory. The energy team expects efficiency to stay at the center of IBM's energy and climate strategy. And as carbon prices raise the cost of fossil fuel and associated energy sources, the financial attractiveness of efficiency investments will increase.

Internal Operations

IBM's energy bill is only a small fraction of the company's $103.6 billion 2008 revenue. This is not unusual—energy has been a relatively small cost factor for most companies, except for the most energy-intensive manufacturers. When viewed this way, it's easy to understand why energy has rarely risen to the top of management priorities.

But context can change everything. IBM's energy bill is a small fraction of its operating costs, but accounts for most of its GHG emissions. In a CO_2 context, energy suddenly becomes the biggest piece of the puzzle. Add to this the fact that the company's energy costs rose more than 60 percent from 2000 to 2007, and it becomes easier to understand IBM's intensified focus on energy conservation.

IBM's energy bill splits roughly among building operations (about 47 percent), manufacturing (about 20 percent), and data centers (about 33 percent). The energy management team, in partnership with the business units, has developed efforts to rein in costs in all three areas. **Table 2** shows how these percentages work out by facility type and by end use. The first four columns of numbers represent the distribution of facility types' end-use consumption: e.g. 20 percent of manufacturing energy use occurs as HVAC versus 25 percent as central utility plant. The fifth (far-right) column shows the total distribution of end-use energy, across all facility types, by total spend. The first five rows show the distribution of end-use consumption by facility type: e.g. 20 percent of HVAC usage occurs in manufacturing versus 10 percent in data centers. The bottom row shows the distribution of energy spend by facility type.

Table 2

Distribution of Energy Use within IBM Operations

	Clusters: Space Types				
Energy Drivers	Manufacturing	Data Centers	Office Spaces	Labs & Research	Total Spend
HVAC	20%	10%	50%	30%	27%
Data Center Equipment	- - -	65%	- - -	25%	22%
Central Utility Plant (CUP)	25%	20%	- - -	20%	16%
Manufacturing Processes and Tools	45%	- - -	- - -	- - -	14%
Lighting	10%	5%	25%	10%	13%
Plug Load	- - -	- - -	25%	15%	8%
Total Spend	30%	28%	28%	13%	

Recreated from image provided courtesy of IBM (2009).

Manufacturing. Making semiconductors means being clean: clean-room environments are a must for these high-tech products. As one example, IBM's Burlington, VT production plant has been finding ways to make the process energy and material efficient as well as clean. Part of the energy conservation gains come from the cleaning process itself. John Aldrich, a 40-year IBM veteran and Burlington energy manager, knew that the site's two production units ran vacuum pumps used by cleaning crews 24-7, like most of the systems that support core production processes. But when he asked the cleaning crews how they actually used the equipment, he found out they only clean a few hours a day. That enabled Aldrich to shut down the vacuum pumps for most of the day, saving over 80 percent of energy use for that system at no capital cost.

But Aldrich's microscope, once focused, discovered much more, including production technologies ripe for change. Semiconductor chip manufacturing involves depositing up to 11 layers of metal on the silicon wafers, each of which is etched into precise patterns that become the chip's electronic circuits. IBM uses dozens of specialized "LAM" (lamination) tools for this critical process, which requires both precise cooling for temperature control and vacuum pumping to remove contaminants. Aldrich's review turned up several technology solutions, including:

- The cooling chillers were expensive to run, and they failed a lot. Aldrich worked with the equipment maintenance team to replace them with solid state models that cost less to run and are very reliable. While it was the energy savings effort that brought this solution to light, it led to product quality and productivity improvements.
- The vacuum exhaust contaminants were destroyed through a heating process, which used lots of energy, and had to be shut down often for cleaning. The energy and equipment maintenance team devised an unheated, chemically-based trap system that used almost no energy and didn't need a cleaning shutdown cycle. Again, the efficiency initiative uncovered a solution that saved energy while improving total performance and productivity.

A clear lesson from IBM's experience is that energy efficiency will be viewed with caution when it introduces uncertainty into a work environment where product quality, production line reliability, and output are the core objectives, and energy management is at the periphery. In these instances, energy efficiency is viewed as part of the support infrastructure, one that might reduce costs on the margin but also poses large and unknown risks if it involves modifying proven practices and technologies. But a surprising find, made by IBM and others in this study, is that the reverse is often true. Instead of detracting from core manufacturing processes, energy efficiency can be like a flashlight that looks inside processes and practices to turn up ideas that not only save energy and money, but also improve product quality, production reliability, and total productivity.

These co-benefits of efficiency are often invisible, until the company's processes, and the minds of those who run them, are opened up to think of energy as just one factor in the total operation. Too often, energy efficiency projects are examined narrowly, on an incremental basis; but when a company like IBM encourages "out-of-the-box" thinking and creates cross-functional teams trained and empowered to look beyond the ordinary, surprising things can happen.

Data Centers. IBM intensified its focus on data centers in 2007 based on its analysis of energy use over the past three years which showed that data center electricity use was responsible for one third of IBM's total electricity use. Around the same time, the Green Grid[4] published a paper on data center efficiency metrics. The paper identified significant opportunities to increase data center energy efficiency and proposed two simple metrics to evaluate the effectiveness of power delivery to support IT operations: Power Use Effectiveness (PUE) and its mathematical reciprocal, Data Center Infrastructure Efficiency (DCiE). These two metrics assess the amount of energy used to run the IT equipment as compared to the total energy consumed by the facility (DCiE). A higher percentage indicates that more power is being directed to the IT equipment to generate useful work. The new Green Grid metrics helped IBM's data center operators evaluate their energy use and assess the opportunities for improvement. When IBM's energy savings goals and reporting system were expanded in 2006, operators were challenged by the fact that data centers and their energy use were growing rapidly, raising concerns about their ability to reach the company's savings goals. Operators said they needed specific metrics to measure efficiency, tools for applying those metrics, and technical help to make improvements.

As a board member of Green Grid, IBM was able to quickly engage these Green Grid metrics, as well as the tools and resources available from the organization and the company's own experts, to help its data centers make efficiency improvements. In the process, the energy team had to address three kinds of data centers: large, central IBM facilities with separate electricity meters; small-to-medium sized centers often embedded in other facilities, typically without separate metering; and client-owned facilities with various metering arrangements. Metering is a threshold requirement for using the Green Grid metrics: to calculate either PUE or DCieE, there must be metering for

4 The Green Grid is a global consortium of IT companies and professionals seeking to improve energy efficiency in data centers and business computing ecosystems around the globe. The organization seeks to unite global industry efforts to standardize on a common set of metrics, processes, methods and new technologies to further its common goals. For more information on the Green Grid, see: http://www.thegreengrid.org/about-the-green-grid.

the total data center, and for the IT equipment separate from the power supply, cooling, and other energy systems in the facility.

The details of measuring and analyzing data center energy performance can be complex. The IBM research team developed a tool, the Mobile Monitoring Technology (MMT), to simplify these efforts. The MMT measures three-dimensional temperature distributions within data centers, using a color-coded display system to identify hot spots that require attention. Other cross business unit efforts in areas such as IT equipment efficiency and virtualization[5] technologies developed other innovations to deliver more computing work for a reduced energy input. The data center team, one of several technical-expert teams within the energy conservation effort, has achieved several successes to date, including:

- The MMT tool has been used in nine of IBM's 60 large strategic data centers, identifying efficiency improvements that would reduce peak demand by seven percent and total energy use by 10 percent. All 60 of IBM's strategic data centers are slated for assessment over the next few years.
- At IBM's Poughkeepsie, NY data center, one of the company's largest, MMT results were used to change equipment configurations, airflow patterns, and air conditioning demand such that one-third of the AC units were able to be shut off. The PUE fell from 1.78 to 1.58, an 11 percent improvement. IBM's goal is to get average PUE's down to 1.42 (DCiE .7), and to build new data centers in the 1.1-1.6 range.
- IBM also applies virtualization techniques in its data centers, redeploying IT workloads to consolidate tasks in fewer servers. In one facility, IBM used virtualization to consolidate workload from servers supporting single applications to servers supporting many applications, reducing the number of servers required to support the workload by 45 percent, freeing up data center infrastructure capacity to expand IT workload capability by a factor of eight with little impact on total energy usage. And when virtualization shifts workloads from older, less-efficient servers to high-efficiency units, additional energy savings are gained.

5 Server virtualization is the practice of shifting from dedicated servers (e.g. one for payroll, one for Internet firewall functions, etc.) to "virtualized" server capacity, where these functions can be handled securely on "virtual" servers, whose data is actually managed across a variety of physical servers. This practice can save energy in two ways: by shifting tasks to newer and more efficient servers, and by loading servers more fully, reducing the amount of energy needed per computing operation.

- IBM is offering MMT, virtualization and consolidation services, and other data center resources to its customers as well, driving substantial improvements in data center operations outside the company.

Building operations. Unlike a heavy manufacturer, where most of the energy is used in a few larger facilities, much of IBM's energy use happens in smaller facilities. The company operates approximately 1,100 facilities in total, including a handful of major manufacturing facilities and over 300 standalone and co-located data centers. To get a better handle on energy use and opportunities in this many facilities of all sizes and vintages, some owned and some leased, the RESO organization began in 2002 to build an energy management organization matrix that cuts across geographic regions—Eastern U.S., Western U.S., Canada, Asia Pacific, Japan, and two regions covering Europe, Africa, and parts of the Middle East. After the expanded reporting and goals program came into effect in 2006, teams were created in technical specialties including lighting, HVAC, central utility plant, compressed air, data centers/IT operations, cafeteria, and office systems. This matrix approach creates both an accountability structure by assigning leads by geography, and a support structure by creating expert teams by technology area. All teams report results to the top RESO executive responsible for energy management. Each team has a technical lead and management lead, with responsibilities to prepare and maintain best practices checklist, research and advise on new energy efficient technologies in the technical specialty and provide technical assistance to site teams.

The technology teams' mission early on zeroed in on developing standardized checklists for operating practices and technology performance. Based in part on team expertise and part on facility energy audits and improvement projects, these checklists leveraged the teams' limited size to provide effective technical assistance for IBM's large real estate portfolio. IBM also follows the "80-20" rule by focusing its most intensive scrutiny on the 210 facilities that account for over 80 percent or more of energy use, putting a limited focus on the remaining facilities. These 210 locations receive detailed onsite assessments using company experts and consultants, are asked to follow energy management checklists in great detail through an online, enterprise level database, and participate in frequent phone and email discussions with the energy team. A snapshot page from the checklists is shown in **Figure 2**.

The checklists are also used to identify projects. To support this effort, RESO invested approximately $9 million, over and above its routine expenditures to operate its ongoing energy conservation efforts, in 2007 and 2008 for energy efficiency projects to supplement the budgets available to individual sites. Results from projects benefiting from this fund are summarized in **Figure 3**.

Figure 2

On-line Global Database

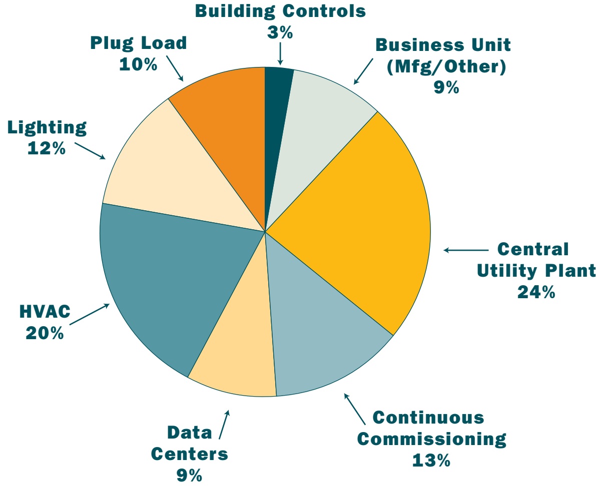
Interior Lighting	Answer	Comments
Have all corridors/aisles, offices, common areas and lobbies been delamped as much as possible?	Yes	
Has a process been implemented to prevent installation of lamps in light fixtures that have been delamped for conservation?	Yes	
Have all incandescent bulbs/lamps been replaced?	Yes	
Have lighting fixture lenses been cleaned (during bulb replacement) to provide maximum illumination?	Yes	
Are exterior window aisle fixtures off during the day to take maximum advantage of daylight harvesting?	Yes	
Do all maintenance areas have lighting timers or sensors installed?	No (in progress)	No. In process. Partially complete.
Have all lighted Exit signs been changed to light emitting diode (LED) type?	Yes	
Is the emergency lighting system for the site designed and operating with the minimum number of fixtures on the emergency system?	Yes	
Do all raised floor and/or lab spaces have lighting control systems or occupancy sensors?	No (not feasible)	No. 24x7 operation
Are lights on to the minimum degree during "after hours cleaning"?	Yes	
NOTE: The conversion of Exit signs to LED types saves $25 per year per sign.		
Exterior Lighting	**Answer**	**Comments**
Are exterior/parking lot lights scheduled for the minimum hours? List the current hours of operation.	Yes	Astronomical timer, hours vary throughout the year. 30 minute buffer.
Have parking lot lighting levels been reviewed recently?	Yes	Reviewed lighting & usage. Disconnected several fixtures.
Are photocells and/or modern astronomical timers installed and working correctly on all exterior parking lot lighting?	Yes	
Have parking lots been consolidated and closed when possible?	Yes	

Low to no cost Items are written in Orange

Recreated from image provided courtesy of IBM (2009).

Figure 3

2008 Energy Conservation Savings by Driver ($K, %)



Total Savings: US$ 3200K

Preliminary Numbers Pending Final Quality Check

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Products and Services

IBM's efficiency learning curve, especially in its IT product designs and data center operations, helped the company sell energy efficiency as both a product feature and as a service offering. In the 1950s, company skeptics opposed IBM's move into computers, but IBM President Thomas J. Watson, Jr. persisted, and the company developed some of the most powerful computers in the world, building a business model around the large, central mainframe computer. Today, the business model has evolved into a much broader vision of intelligent systems building a "Smarter Planet" based on pervasive computing ability. This model integrates electronics as small as the microchips in our cell phones, the blade servers that act as the brain cells in the data centers that host much of the Internet, and IBM's Blue Gene supercomputers that support the leading edge of scientific research.

The Blue Gene is the kind of supercomputer that makes electric utilities take notice. In large research institutions like Los Alamos National Laboratory it draws peak power demands above two megawatts. But Blue Gene and other IBM technologies have helped cement IBM's place as the global leader in supercomputer energy performance. IBM-built systems hold 22 of the top 25 spots on the "Green 500" list of most efficient large computers, maintained by nonprofit industry group Green500.org.[6] Its best system, at Forschungszentrum Juelich (FZJ), produces over 720 megaflops per watt of power demand (a megaflop is one million instructions per second). At full power, this system drives 43.4 teraflops (trillion instructions per second) of computing capacity—almost 40 million times better than its early-1970s ancestor, the IBM System 370, which was considered groundbreaking technology for its day at one megaflop.

6 From the November 2009 "TOP Green 500 List": http://www.green500.org/lists/2009/11/top/list.php?from=1&to=100.

But for all the dazzle in IBM computers' energy performance, the company's hardware products, accounted for only about 20 percent of the company's 2008 revenue. IBM's portfolio of customer offerings go far beyond hardware, into integrated hardware, software, and service solutions that cut customers' energy costs while solving their computational, business process and data management challenges. Under its "Smarter Planet" campaign, the company aims to build intelligence into societies' systems—from public health to agriculture, from traffic management to the electric power grid—in order to enable integrated solutions.

Energy efficiency is a core value of several IBM solutions. It starts with product design: IBM's longstanding commitment to research and development keeps it actively engaged in expanding the computing power of its products while reducing energy use. This is driven not just by IBM's product stewardship goals, but also by product performance needs. Heat is an enemy in electronic circuitry: too much heat harms performance and can lead to failures. IBM's product development team works relentlessly, through simulations and physical tests, to reduce "hot spots" in microcircuit designs, and to refine today's multiple-core chips that allow energy use to scale up in proportion to changing computing needs.

IBM product engineers readily admit, however, that the hardware is not the whole solution. While "cooler," multi-core chips can produce servers that are 10 times as efficient as older units, it is how the whole system is used that drives actual energy use. This effect shows up dramatically in customer use of servers, the brains of today's data centers. As servers have evolved, many customers have kept certain functions running on single servers, and in the process accumulated a collection of servers, many older and less efficient, each running at only part of its capacity. But with today's hardware-software integration capabilities, IT functions can be loaded onto various servers in a more intelligent fashion, using the concept of "virtualization," which puts more computing operations onto fewer servers.

Virtualization allows more optimal loading of server capacity, running many fewer servers to meet total enterprise needs. This saves energy, and server capacity, reducing both hardware and operating costs. In its ultimate form, virtualization merges into the "cloud computing" realm, where data is no longer stored on specific hard drives or servers, but on an Internet-based storage network spread over data centers worldwide. By reducing the number of physical storage devices and increasing utilization of high-efficiency data centers, this approach can continue to increase the energy efficiency of personal computers and larger IT systems alike.

IBM markets advanced data center solutions across many markets: a recent TV advertising campaign shows hard-nosed corporate executives seeing animated birds and flowers after they are told that this kind of solution can cut their energy costs up to 40 percent. In these product and service offerings, it is possible to detect some of the same core principles IBM applies to its internal energy conservation strategy: make the system more intelligent by collecting the right information from the right points in the system; scale energy use to only the amount needed to support the work; and apply technology as part of larger, integrated solutions.

Supply Chain

In 2008, IBM's Global Procurement spend was $38.5 billion. The company's supply chain is one of the world's largest and most complex, consisting of more than 30,000 supplier locations spread out over more than 60 countries. Supply chain management is part of IBM's Corporate Responsibility program. IBM tracks environmental performance of its suppliers and regularly audits suppliers against its supply chain principles.

IBM's production supplier base has shrunk in relative terms as the company's business mix continues to transform to include not only manufactured products but increasingly software and service solutions. But the company continues to be a supplier of electronic components to other manufacturers and sells computer servers, storage products and retail solution products. Because it recognizes its ability to influence supplier performance, IBM has been active in developing the electronics industry's supply chain sustainability practices. These efforts are channeled through the Electronics Industry Citizenship Coalition (EICC). Along with other major component and product manufacturers, IBM has invested substantial time and resources in co-developing and adhering to the EICC's Code of Conduct.

The EICC Code of Conduct covers a wide range of social and environmental responsibilities, including energy efficiency. IBM employees participate in EICC's Environmental Sustainability Working Group (ESWG), which is working to establish specific supplier environmental review items or metrics. The group's first assignment resulted in development of the EICC carbon reporting system launched in June 2009. This is an on-line, packaged system through which Tier 1 (or direct) suppliers can disclose their GHG emissions inventory for use by all EICC companies who purchase from that supplier. The intent is to create a system in which suppliers can provide their data once in a standard format for use by its full set of customers. Each company using the system will ask its Tier 1 suppliers, the direct suppliers to that company, to disclose their enterprise level GHG emissions inventory. These "Tier 1" suppliers are then asked to reach out to their direct suppliers to also disclose their inventories through the system. The system is also capable of collecting information down to the facility level. EICC members are not requiring more detailed disclosure at this time, but the energy and GHG emissions reporting system creates a framework in which additional data could be disclosed in the future.

IBM has also surveyed its Tier 1 suppliers in 2008 and 2009 as a participant in the Carbon Disclosure Project's (CDP) Supply Chain Project. In 2009, IBM invited over 120 of its major suppliers, representing 80 percent of its expenditures with production-related suppliers and 30 percent of spending with services/other suppliers, to respond to the CDP Questionnaire. IBM got a 73 percent response rate, up from 63 percent the year before. IBM wanted to work with critical suppliers to understand their operational impacts and assess where they are with GHG emission inventories and reduction plans. The survey responses for the 2008 year showed that about one-third of production suppliers had reduction plans, and about one-half of non-production suppliers had plans.

Conclusions

As a leader in the 21st-century information economy, IBM has used information tools to drive its efforts in environmental management, including energy efficiency. Some of these innovations, especially in data centers and other IT operations, have enabled IBM to develop solutions to help its clients improve their operations and environmental and energy performance. Part of the company's Smarter Planet campaign relates to resource conservation in areas like energy, water and environmental performance improvement. Like other companies in this study, IBM also found out that people are as important as technology in an effective efficiency strategy. Even in its highest-tech clean room semiconductor manufacturing, some of the largest energy savings came from collaborating with people inside the operation, evaluating and pursuing opportunities, and adjusting energy systems based on actual operational needs. The energy team also found that people responded with surprising enthusiasm to the energy savings effort, and in many cases came up with innovative technology and operating ideas that not only saved energy, but also improved productivity and morale.

Key lessons learned from IBM's energy efficiency successes include:

- Encouraging outside the box thinking on energy efficiency can lead to unforeseen business benefits. In IBM's case, energy efficiency served as a flashlight that led engineers and others to reevaluate existing processes and make improvements that not only saved energy but also led to production and quality improvements.
- Leverage internal energy efficiency expertise to exploit new business opportunities. IBM's success in reducing energy use in its own data centers helped put it in a position to offer new products and services to clients seeking similar results.
- Take advantage of the fact that energy use is something that all your employees have some influence over. Employees have shown themselves willing to rally around energy efficiency as a way to solve problems and be a part of something bigger than what their specific job description calls for. Efficiency can also act as a strong social glue within the corporation, and lead to improved employee morale and greater worker retention.