Campus Energy Cost Savings Case Studies: Applications of Energy Best Practices

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ABSTRACT

Global businesses continue to experience regular and significant cost increases in energy costs. Most companies have established energy and environmental sustainability commitments/policies which address decreasing energy emissions and indirectly lower costs. At Armstrong, a corporate goal was established in 2008 to reduce greenhouse gas emissions 10% from 2006 baselines by the year 2015.

In 2009, Armstrong completed a greenhouse gas inventory third-party verification from the established 2006 baseline year through 2008. Our partnership with *The Climate Registry* assisted in ensuring measurement accuracy. While the corporation had already surpassed the 2015 reduction goals, the achievement was largely a result of a decrease in manufacturing production tied to the overall downturn of the economy. The company continues to be committed to projects that decrease energy usage and our environmental impact.

COMPANY AND ORGANIZATION

For 2009, Armstrong's net sales totaled just under $3 billion. Founded in 1860 and based in Lancaster, Pennsylvania, Armstrong currently operates 39 manufacturing plants in 10 countries, with approximately 13,000 employees worldwide. It will celebrate its 150th anniversary in 2010.

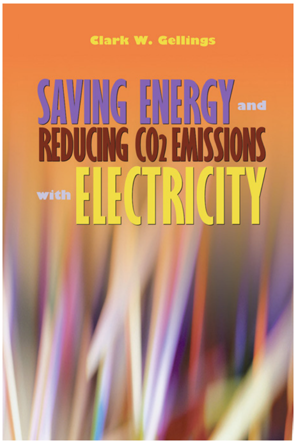
Armstrong's campus center and corporate headquarters is located in Lancaster, Pennsylvania. Campus facilities are sited on a 625-acre plot, with approximately 150 acres of developed property including buildings, roadways, and parking areas. There are 22 buildings, enclosing about 1,000,000 square feet of conditioned space for about 1,350 employees. The buildings range in age from those initially constructed in 1950 to the newest corporate headquarters, Building 701, completed in Dec 1998. The campus spends more than $2.8 M annually for energy, mostly for electricity and natural gas.

In 2007, Armstrong initiated several projects at its corporate campus to continue process improvements that reduce energy usage and costs. This article describes these projects and the energy cost reductions that resulted from their implementation. Together, these projects have resulted in significant energy usage reductions—more than 2,950,000 kWh, about a 16% overall reduction compared to the 2007 base period. Since Pennsylvania regional electric rate cap expiration at the beginning of 2010 significantly increased electrical costs, the annualized electricity cost savings will be about $280,000 this year. Aggregate annual savings, including boiler fuel savings, are expected to be about $327,000, or 11.6% of total campus energy costs in 2010 as compared to 2007.

The Facilities Management organization supports business unit staff requirements and manages corporate facilities at the campus center. Services provided include building and equipment maintenance; HVAC management; capital improvements and project management; mail and copying; and security. The organization's goal is to meet and exceed campus customer needs in support of business unit and corporate goals.

Figure 1. Armstrong Campus Aerial View

Saving Energy and Reducing CO_2 Emissions with Electricity



Clark W. Gellings.

Through different applications, electricity provides the energy required for light, heat, comfort, and mechanical work. In order to sustain society's expectation for comfort, convenience and productivity, it will remain necessary to continue to seek and find reasonable quantities of energy in forms which are accessible, affordable and have modest or zero environmental impacts. Without question, this need will lead to increased electrification, and a decrease in—and possible elimination of—the use of fossil fuels. This in turn will call for an international imperative to make existing uses of electricity both efficient and practical. This book guides the reader toward a clearer vision of that goal, with explanations of the concept of electrification, along with CO_2 reductions through expanded end-use applications of electricity. Topics include electric cars; airport, seaport, railroad and mining electrification; industrial uses of electricity in a variety of processes; residential building use of electricity; and enhancing energy efficiency and demand response.

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STRATEGIES BACKGROUND

In support of corporate sustainability and greenhouse gas policy, Armstrong's Facilities Management organization follows an energy policy and strategy that *forces* consideration for lowering costs and achieving energy savings in these areas:

- **Energy Purchasing**. Procure energy (electricity, natural gas, and fossil fuels) at the best price from utility suppliers.
- **Manufacture of Utilities.** Produce within the facility, using purchased energy, the lowest cost manufactured utilities for end-users. Manufactured utilities include steam, chilled water, and compressed air.
- **Efficient Utility Distribution**. Energy distribution systems require periodic re-evaluation, regular maintenance, and right-sizing to maximize efficiency, waste reduction, and system loss avoidance. These systems include all manufactured utilities, as well as purchased electricity, natural gas, and fossil fuels.
- **Optimized Load Utilization**. This is for all energy-consuming loads when reaching the end-use equipment, its final destination, in each energy distribution system.

Each of these points is an important element in the overall campus/organizational strategy to manage and reduce energy costs. There are best practices involved in implementing and achieving each element.

Purchasing

There are two components to the Energy Purchasing element:

(1) Utility Supplier Purchases

For most organizations and manufacturers today, this job function has become a professional staff resource responsibility. In today's de-regulated markets for electricity and natural gas, getting the best pricing—both today and in the future—is a great challenge. When facilities are located in multiple states, specific knowledge of local and regional regulatory laws, utility tariffs, and pending regulatory change must be considered.

(2) Equipment Procurement

With the Energy Independence and Security Act (EISA) going into effect in December 2010, equipment efficiency standards and life cycle costs must be included in procurement decisions. In most cases, the premium costs paid for more efficient equipment is cost effective and easily justified. Examples include motors, fans, compressors, chillers, electrical transformers, lamps, ballasts, etc.

Manufactured Utilities Steam

Low-cost steam requires fuel efficient boilers (high efficiency burners) that are correctly sized, regular maintenance, and efficient supporting equipment—fan systems (FD, ID, and combustion), feed water pumps, other motorized systems, instrumentation and controls, etc.

The steam distribution system is also an important component that requires constant monitoring and regular maintenance throughout the year. Checking and repairing steam traps, leak detection and repair, and insuring insulation integrity are the main ways to avoid culprits that waste energy.

Chilled Water

Producing chilled water, particularly at a central chiller plant, is an energy-intensive process. Plant electrical operating costs increase significantly during the cooling season. Water consumption (used for make-up in the cooling towers) also increases dramatically. Energy efficient chillers, especially at part load operation, VSDs controlling pumping, and cooling tower processes are essential to optimize total system costs.

Energy Utilization

For all energy utilities consumed, the end-use equipment and processes should be regularly evaluated and upgraded or replaced to minimize waste and losses. Installed equipment should comply with recent energy codes and EISA guidelines, as well as be Energy Star-labeled labeled and meet or exceed local utility rebate requirements, where available. If the end-use device meets these criteria, optimization of operation becomes the control element that determines overall energy use and cost. Everything must be considered.

ENERGY STAR® and BEST PRACTICES

ENERGY STAR® is the federal government's program administered by the U.S. Environmental Protection Agency (EPA) and the Department of Energy (DOE). The program helps businesses and building owners to protect the environment through superior energy efficiency. A key element of ENERGY STAR is EPA's National Energy Performance Rating System for buildings, introduced in 1999. The online benchmarking tool, Portfolio Manager (PM), permits building owners and facility managers to enter specific data (energy consumption, operating hours, occupancy, and geographic location) and compare a building's energy performance against the performance of similar buildings across the country. The building receives an ENERGY STAR rating from 1 to 100 based on one year's energy consumption. The EPA awards a STAR label to owners of buildings whose performance score is among the nation's top 25% (equal to an energy performance score of 75 or greater on a 1 to 100 scale) while maintaining a healthy and productive indoor air environment.

Figure 2. Bldg 701 (left) and Bldg 5B

Armstrong has two buildings located on the corporate campus which have earned Energy Star® labels. The corporate headquarters, Building 701, achieved LEED EB Platinum certification in 2007. As part of the scoring process for Energy and Atmosphere Credits in the LEED application, it achieved the Energy Star® Label in 2006. The building subsequently achieved an Energy Star label in 2008 and 2009. A different office facility, Building 5B located on the same corporate campus, also achieved the label in 2009. Many building operating procedures, equipment improvements, and environmental control EMS practices have resulted in campus best practice procedures for all facilities that utilize the campus energy management system.

Figure 3. Energy Star® and LEED Plaques

ENERGY BEST PRACTICES

Armstrong launched an integrated corporate sustainability policy in 2007 that extends the accountability of energy stewardship with goals to reduce greenhouse gas emissions in the future. This policy sets goals that support the broader goals of the company for driving innovation with energy saving products, manufacturing with less energy, and considering energy with capital investments. Energy management activities are key to achieving company-wide GHG reduction goals.

Policy and Goals

Armstrong's Energy and Greenhouse Gas Policy requires:

- Global energy management programs
- An energy review for new products and capital investments
- Measurement of energy and greenhouse gases (GHG) according to the Global Reporting Initiative
- Established goals for our carbon footprint
- Transparency and external reporting of GHG inventory and progress on reduction

Implementing this policy has shown significant results in the first few years of implementation. In 2009, greenhouse gases were reduced by 200,000 tons, the equivalent of more than 23,000 homes' electricity use. The stated corporate goal is to reduce GHG emissions 10% by 2015, using 2006 as the baseline year.

Measurement

For an energy management plan to work, it must incorporate information on past and current energy usage. Measurement devices and a timely reporting process are required to maintain and benchmark performance and identify operating issues when they occur. Energy sub-metering systems monitor refrigeration and chilled water systems by building, HVAC, building electricity, lighting, water, and to a lesser extent, steam usage. Monthly data are used to allocate energy costs (energy accounting) and to develop energy profiles both for each building and for aggregate campus energy usages. Building performance is reviewed at least monthly, making comparisons to previous years' performance. Equipment changes and improvements are considered when making these comparisons.

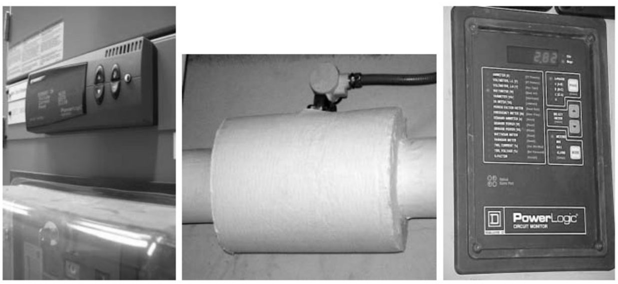

Figure 4. Electrical and Steam Meters

Energy Systems to Consider

All systems within a facility which use energy must be included in the application of best practices decisions:

- Buildings
  - HVAC and lighting systems
  - LEED™/ASHRAE/green/sustainable building codes
- The manufacturing process
  - Utility services required—options using lowest cost per MMbtu
  - Make-up air, conditioned air, heat recovery opportunities
- Equipment purchasing/energy procurement
- Steam and boiler systems
- Motors, pumps, and fans
- Compressed air systems
- Electrical equipment

Greenhouse Gas Emissions

(assessment with regards to the usage of Electricity, Gas, Oil, Water, Lumber Etc._)

Date		Project Number:	
Division:		Project Engineer	
Plant		Division Engineering Manager:	
Bldg. Location and Bldg. No.			

Summary of Estimated Energy Usage

Indirect Energy - (Values to be converted into direct energy units for Cost assessment)

		Current Usage	Proposed Usage	Change	Units
Compressed Air					CFM
Process Hot Water					BTU's
Chilled Water					BTU's
Tower Water					BTU's
Other					

Conversion	Units
	KWH
	MCF or Gal
	MCF or Gal
	MCF or Gal

Direct Energy

Used in the manufacturing and required pollution control processes

	Rate ($)	Current Usage	Proposed Usage	Change	Units	Resulting Annual Cost ($)
Electricity					KWH	
Natural Gas					MCF	
Fuel Oil					GAL	
Wood Waste					BTU's	
Other						

Total Direct $ =

Total Estimated Energy Cost $

Summary of Greenhouse Gas Emissions

Indirect Energy	tons
CO2	0
N2O	
CH4	

Direct Energy	tons
CO2	0
N2O	
CH4	

Figure 5. Energy Review, EHS Checklist

Energy Review for New Products and Capital

As part of the sustainability policy, the requirement to perform an energy review for capital investments and for all new products was integrated. For capital project appropriations exceeding $50,000, an environmental, health, and safety (EHS) checklist, Figure 5, must circulate and be approved with the funding request.

CASE STUDY EXAMPLES

As outlined earlier, Armstrong has been implementing energy reduction projects and continuously optimizing processes and operations for several years. Since initiating the LEED certification and Energy Star® labeling processes in 2006, Armstrong has completed numerous projects at the campus.

Lighting

Campus-wide lighting projects are on-going, in conjunction with the accelerating lighting technology hardware (lamps and ballasts) and control product improvements that come regularly.

Since 2007, the campus has standardized with linear fluorescent T8 and T5 lamps, compact fluorescents for most incandescent applications, metal-halide sources for outdoor applications, and more recently, LED sources. Considering just the linear sources, about 8,000 lamps have been replaced (FO28 watt, 3,500K lamps, replacing 32 watt lamps), reducing demand by 32 kW and saving $12,000 annually.

Lighting control strategies incorporate ASHRAE 90.1 design standards and usually exceed the standard to qualify for EPACT tax credits (extended through 2010). This includes the application of dimmers, personal controls (task light switches), daylight sensors, occupancy sensors, and zone and whole-building controls.

Motors

NEMA Premium™ Energy Efficient Motors are required for most new equipment purchases with motors of 10 horsepower and larger. This standard is included in the purchase specifications and itemized in the EHS checklist for project energy review. *NEMA Premium*™ is also the standard for replacing failed motors, especially if they operate for more than 2,000 hours per year (one shift).

HVAC and pump motor retrofit projects have been completed in some buildings. In all these projects, variable speed drives (VSDs) were also installed with the motor replacements. In two recent building projects, B301 and B4, fan and pump systems were upgraded. Electrical power and chilled water reductions were about 700,000 kWh, with annual savings of $67,000. This includes reduced chilled water usage when air handlers condition lesser volumes of air. With lower chilled water demand, the throttling control valves were also replaced with VSDs.

In the boiler plant, B4, pressure-reducing valves (PRVs) for feed water supply were replaced with VSD pump drives and NP energy efficient motors. This upgrade resulted in about $118,000 kWh power reduction, saving $11,000 annually.

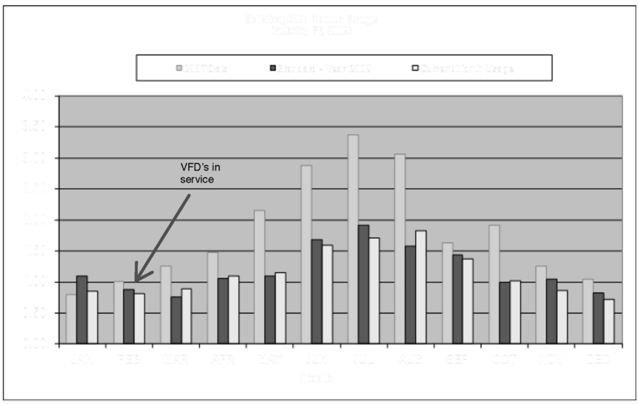

Figure 6. Three-year Usage Profile

Figure 7. Energy Efficient Motors

Variable Speed Drives

For most variable torque, horsepower applications, variable speed drives are specified. This encompasses most air handlers and pumping systems, control valve throttling applications, PRVs, and air damper replacements.

Chiller Upgrades

The campus central chiller plant uses three water chillers, with total capacity of 2,500 tons. In 2008, a new 1,000-ton variable speed chiller was installed, replacing one of the original 15-year-old centrifugal chillers. The new chiller is 8% more efficient (.58 kW/ton), reducing energy usage by 694,000 kWh and saving $65,900 (2010$).

Compressed Air

A relatively small air system is required to supply pneumatic control system air, and some process air, to research facilities in parts of the campus. In about 2002, two 100-hp, reciprocating machines were replaced with twin, 75-hp, two-stage rotary screw machines. The manufactured source for compressed air is now more efficient, producing air at a lower cost. This project was a capital improvement, not driven by energy costs, but it did result in overall savings.

A subsequent project, installed in 2006, is an automated plant pressure regulator, which changes air pressure setpoints in the distribution system from 80 psig during occupied periods, to 65 psig during off-hour periods. The system is controlled by the campus building automation system (BAS) and saves $4,400 annually.

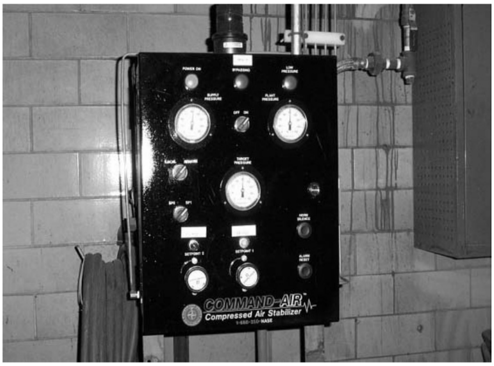

Figure 8. Compressed Air Pressure Controller

Electrical Transformers

There are two transformer issues to consider for all transformers installed throughout a power distribution system. First is the issue of connected (or installed) substation capacity, compared to required capacity (or actual loads) for each building or process application on campus. The second issue addresses the type(s) and transformer design—TP compliant, EPACT compliant, and less than 150 degree temperature rise for each application.

Three substation transformers with 4,500 kVA capacity have been eliminated from the campus infrastructure. Loss elimination is estimated at 12.5 kW, with an estimated electrical reduction of 110,000 kWh, saving about $10,500. One of these subs, a 2,500 kVA device (see Figure 7), had less than 100 kVA of load before the secondary was recircuited.

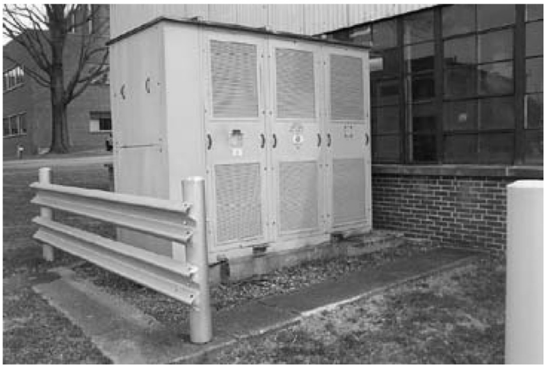

Figure 9. 2,500 kVA Transformer

For other transformer applications, transformer efficiency and temperature rise should be considered. It is best to obtain this data from manufacturers when comparing same capacity transformers. If data are not readily available, temperature rise is an indicator of transformer efficiency. A transformer with an 80°C rise uses 13-20% less operating energy than a 150°C unit. These types of transformers should always be used in confined spaces—electrical rooms, underground vaults, and air-conditioned spaces. High efficiency translates to less waste heat, lower HVAC requirements, longer life, and lower energy costs.

Daylight Housekeeping

Beginning in June, the outsourced campus janitorial services staff began cleaning campus office spaces during daylight hours—called *daylight housekeeping*—instead of at night. This procedural change was implemented to reduce energy usage, greenhouse gas emissions, and be conscientious of cost and the environment.

Initial unoccupied building schedules were modified to reduce HVAC system operating times by about 20 hours per week. During the seasonal transition period in the fall months, some daily schedules were lengthened. The current average is about 18 hours less each week. Fewer operating hours obviously reduces air handling unit (AHU) electrical energy requirements. It also reduces chilled water requirements—cooling energy, reheat energy, and heating energy—for these hours. Table 1 summarizes reductions in affected buildings.

Table 1.
Summary of Energy Savings By Building for Daylight Housekeeping

2010 Building Energy Usage								Schedule Savings
Building	AHU KW/hr	Air Cond Tons/hr	Total KW	AHU Steam/hr	Power Costs/hr	Steam Costs/hr	Total Energy Costs/hr	18 hours / weekly sav
1,2,3	70	200	270	1,500	$25.65	$12.00	$37.65	$33,885
5A	40	20	60	500	$5.70	$4.00	$9.70	$8,730
5B	90	90	180	500	$17.10	$4.00	$21.10	$18,990
301	80	90	170	1,500	$16.15	$12.00	$28.15	$25,335
401	40	70	110	500	$10.45	$4.00	$14.45	$13,005
402	80	50	130	500	$12.35	$4.00	$16.35	$14,715
701	150	150	300	1,500	$28.50	$12.00	$40.50	$36,450
TOTALS	**550**	**670**	**1,220**	**6,500**	**$115.90**	**$52.00**	**$167.90**	**$151,110**

The energy best practice approach embraces many elements that collectively help a business achieve efficient operation and lower energy costs. It starts with a strategic business plan that incorporates policy and goals to reduce energy usage. Purchasing utility-supplied energy or producing required utilities "inside the fence" at the lowest cost is the first issue to manage at the facility level. Distributing energy to the end users and consuming equipment requires that electrical, steam, air, and chilled water systems be properly sized and regularly maintained. Finally, the processes and equipment using that energy should be regularly evaluated, updated, and replaced as improvements become available. Measurement systems must be in place to verify performance, establish baselines, and provide the energy information to manage all these systems.

Table 2. Energy Savings Summary

Practice	Location	kWH Savings	Steam saved	Total $ Savings
Lighting	Campus	126,000		$12,000
Motors & VSD's	Bldgs 4, 19, 301	759,000		$72,100
Chiller Upgrade	B501	694,000		$65,900
Electrical Transformers	Campus	110,000		$10,400
Energy Star® Optimization	B19 & 5B	124,000		$11,800
Compressed Air	Campus	42,000		$3.900
Daylight Housekeeping	Campus	1,100,000	5,800 M lbs	$151,000
TOTALS		2,950,000		**$327,000**

RESULTS AND CONCLUSIONS

Utility source reductions and energy cost savings from best practice implementations over the past few years are summarized in Table 2. Many of the initial concepts that are now parts of best practice processes for Armstrong businesses originated with the Energy Star labeling process for buildings. For beginners looking to incorporate best practices, understanding Energy Star benchmarking tools is a good start.

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ABOUT THE AUTHOR

David A. Eberly, P.E., C.E.M, GBE, CEA, C.S.D.P., currently serves as a principal engineer in Corporate Facilities Management for Armstrong World Industries, Inc., a global manufacturer of resilient floor coverings, wood flooring, ceilings, and cabinetry. At Armstrong for over 35 years, Dave has held electrical, facility engineering, and energy management positions, including that of corporate energy engineer. In his current position, he managed a 2,000-kW distributed generation installation, reducing corporate campus electrical costs by 25%. A trained Green Belt, he implemented Six Sigma process improvement projects over a two-year period at the same corporate campus that are saving about 12% of annualized electrical energy costs. As a LEED™ EB team member, he achieved the Energy Star® label for Armstrong's corporate headquarters building in Lancaster, Pennsylvania, which also achieved the prestigious LEED™ EB *Platinum* certification in 2007. For these achievements, Dave was recognized as Energy Engineer of the Year in 2008 by the Association of Energy Engineers. Energy Star® labels were subsequently achieved in 2008 and 2009 for the corporate headquarters building and for Bldg 5B, another Lancaster campus office building, in 2009. He currently serves as president of the Central PA Chapter of the Association of Energy Engineers (CPAEE).

Dave is a graduate of Pennsylvania State University, with a B.S. in electrical engineering and an M.A. in business administration. He is a registered professional engineer in Pennsylvania, a Certified Energy Manager (CEM®), a Green Building Engineer (GBE™), a Certified Energy Auditor (CEA), a Certified Sustainable Development Professional (CSDP), a member of ASHRAE (American Society of Heating, Refrigeration and Air-Conditioning Engineers), and a life member of the AEE (Association of Energy Engineers).

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