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6 Steps To Successful Facility Energy Management

By **Mike Moran** and **Marc Berman**

Buildings use about 40% of the energy consumed in the United States and 72% of the nation's electricity. Buildings also account for 80% of all electric expenditures.[1] As utility bills skyrocket, controlling energy costs is paramount for maintaining and operating facilities. Equally important is demonstrating return on investment for new energy-saving equipment and approaches, while meeting increasing requirements for environmentally sound energy use.

Most organizations welcome innovations to reduce energy use, but have a limited budget to test and implement them. It also can be difficult to justify the initial investment for new energy equipment and programs. And, anything done to save energy can't constrain the organization's bottom-line capability to make a profit and serve its customers.

Energy managers and engineers at a mixed-use facility in Richland, Wash., have developed a six-step energy management program that addresses these challenges. Elements of the program can be adapted for businesses of any size.

Pacific Northwest National Laboratory (PNNL) is a multiprogram facility in southeastern Washington State that is operated for the U.S. Department of Energy's (DOE's) Office of Science. PNNL has about 2 million gross square feet of mixed-use space in 84 government and private buildings occupied by 4,000 staff, using 72 million kWh of electricity for $8.4 million in utility costs annually.

About the Authors

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With double-digit increases in utility costs, PNNL reduced energy consumption per square foot by 38% in office buildings since 1985 and 42% in lab space since 1990. The laboratory has been honored for exemplary energy management by the International Facilities Management Association, the Association of Washington Business, the U.S. DOE, and the U.S. Environmental Protection Agency.

Experience at PNNL has revealed six steps for successful energy management:

1. Changing staff behavior;
2. Recommissioning facility systems;
3. Modernizing the infrastructure company-wide;
4. Diversifying energy supplies;
5. Using alternative financing; and
6. Evaluating effectiveness.

This article explains how to translate these principles into the practical steps necessary to implement a sustainable energy management strategy.

Changing Behavior

Influencing staff behavior is arguably the most difficult aspect of energy management, but it can also be the most productive.

It's important to get buy-in from the top. The first step is to document what kind of energy the facility uses and when, how the facility compares with others that are similar, and how to improve. Facility managers can use these facts in a plan that describes long-term strategies for conservation, building and system upgrades, energy diversification, and communication. At PNNL, the plan helped show top management that increasing energy efficiency would result in substantial cost reduction without compromising research facility operation. Management then endorsed the plan, committing to make operational changes to reduce energy and maintenance costs with the underlying goal of reducing utility costs.

The plan spells out goals and ways to measure progress. At PNNL, the original goals included reducing energy consumption per square foot in laboratories and office buildings compared to a baseline year, reducing water use in landscaping and building processes, and increasing staff awareness about actions they could take to reduce energy costs daily. Energy goals are written into annual performance evaluations for staff and organizations.

An important aspect of motivation is emphasizing the power of the individual, both detrimental and beneficial. The staff was told that if one person in 10 at PNNL leaves equipment and lights on in his/her office 24 hours per day, it adds an additional $100,000 per year to energy costs. Staff learned about energy goals, tips, and progress through e-mail messages, staff meetings, presentations, monthly displays noting progress, a Web site (www.pnl.gov/conserve-energy), and PNNL's staff newsletter.

At PNNL, staff engaged directly through an energy-saving competition among eight office buildings. At the end of each of three winter months, occupants of the winning building received donuts and bagels. After three months, occupants of the overall winning building received a catered lunch.

This pilot effort was tremendously successful. Energy use dropped by 20% in one building and 14% in the others, when compared with previous years. A $4,000 investment generated a savings of $16,000 over three months, a 400% return on investment. Unfortunately, once the competition ended, energy use crept back up to historical levels, partly because of a high rate of staff moves that brought uninitiated people to the buildings. The lesson here is that long-term behavior change requires continuous education and involvement.

A number of years ago, a third-party energy audit showed that plugged-in equipment was responsible for 35% of total office building consumption at PNNL. The top contributor was office computers—an average of 2.6 per staff member. Based on this finding, facility managers created a two-year Plug into Savings project to reduce unnecessary computer use. PNNL worked with a regional utility, the Bonneville Power Administration, to distribute more than 2,700 motion-controlled power strips to staff at PNNL to reduce standby power/plug load requirements in offices. Five hundred underused, operating computers also were eliminated, further reducing wasted energy. The results of this two-year project were dramatic. Savings showed an estimated 2.9 million kWh reduction, with $118,728 in cost savings the first year, which is a 2.7% reduction per square foot.

Finding More Efficiencies

Recommissioning is one way to reveal energy-saving opportunities in existing buildings. At PNNL, recommissioning started by making a checklist of no-cost or low-cost energy-saving strategies, based in part on the database of DOE's online Industrial Assessment Center. Actions included fine-tuning HVAC systems, adjusting temperatures, using night temperature setbacks, turning off unneeded lights after hours, and reprogramming heating and cooling systems to shut down based on outdoor air temperatures. With checklist in hand, facility managers could systematically inventory energy use in their buildings and take actions to reduce it. The master checklist also included larger efforts costing $1,000 or more, which were planned for and executed separately from the less costly items.

The master checklist is updated regularly as new opportunities for energy savings are identified. Over a five-year period, PNNL's recommissioning activities resulted in an estimated energy cost avoidance of more than $1 million since fiscal year 2000. Some of these dollars were used to purchase renewable energy. Recommissioning also helped get facility managers more involved in all phases of building operation, as they seek energy conservation from design through procurement, operations, and maintenance.

The savings were particularly impressive for one large building that accounts for a quarter of total energy consumption on the PNNL campus. The 200,000 ft^2 (18 600 m^2) Environmental Molecular Sciences Laboratory (EMSL), a DOE national scientific user facility, uses 472,000 Btu/ft^2 (5360 MJ/m^2) of energy annually (*Photo 1*). One low-cost but effective action was simply to clean the four-acre white roof regularly to increase solar reflectance. In the sunny climate where EMSL is located, an infrared thermometer showed that a clean roof was 35°F (19°C) cooler than a dirt-darkened one.

Other no- or low-cost measures taken at EMSL were adjusting the building and system temperatures, fine-tuning HVAC systems,

Photo 1: Significant energy costs were avoided at EMSL, a 200,000 ft² national scientific user facility for research, despite energy-intensive equipment such as supercomputers.

implementing night setbacks on thermostats, turning off lights not needed during day shift and after hours, and reprogramming digital controls to shut down heating and cooling water loops based on outdoor air temperatures. Staff were appointed to identify additional operational improvements. Together, these measures resulted in lower-than-expected energy costs every year, with more than $400,000 in avoided costs over a five-year period.

In addition, a cooperative research project with a commercial company is investigating how an innovative evaporative cooling technology may reduce energy use in a supercomputer housed at EMSL (*Photo 2*).

Going Company-Wide

Sometimes it's necessary to go beyond recommissioning individual buildings to make company-wide upgrades. For example, PNNL's internal network was used to set all computer monitors to go into hibernation mode after 20 minutes of non-use. In addition, computer users were encouraged to upgrade from CRT monitors to the more energy-efficient LCD monitors as soon as they were commercially available. Since 2005, PNNL's computer purchasing program has switched to LCD monitors.

Water heater thermostats were lowered to 110°F (43°C) for tanks serving restrooms and kitchens. Occupancy sensors to control lighting were installed in common areas. Lighting fixtures were retrofitted to more efficient technologies. Office light fixtures were reduced from four lamps to two where appropriate. These lighting retrofits paid off in less than three years.

As a research laboratory, PNNL seeks out in-house opportunities to pilot-test new energy technologies. One two-story, 70,000 ft² (6500 m²) steel-concrete building needed new temperature sensors, but a conventional wired system (10 temperature sensors) would have cost $8,400 to install. The commercially available wireless system PNNL selected (32 temperature sensors) cost $6,000, plus the cost of changing batteries every three to five years. *Figure 1* shows an example of the network topology in one building. One innovation was enabling all the components of the system to communicate with each other, which made all the components of the HVAC control system work together seamlessly.[2]

Three times as many temperature sensors were installed, enabling each zone's temperature sensors to be averaged, which provided a more accurate representation of the true zone temperature. This eliminated many of the hot/cold complaints because the HVAC systems no longer overheat or overcool spaces. In addition, the new system shows where existing equipment is not working properly, so timely adjustments can be made.

The payback was less than 12 months on the initial installation, followed by cost savings of more than $6,000 per year.[2] Now, eight buildings that had a history of temperature complaints run more efficiently with wireless systems.

One lesson learned was the importance of communicating with staff when systems are installed. When it became apparent that some staff believed the wireless sensors were actually audio-recording devices designed to monitor staff behavior, extra care was taken to communicate the real purpose of the devices. The same careful communication was necessary when occupancy sensors were installed in bathrooms; some people initially thought the sensors were cameras.

A more recent wireless technology is a rollup door switch tied into the room HVAC. When the door remains open for at least five minutes, the HVAC system shuts off, saving energy and run time.

Photo 2: As part of a collaborative PNNL research project with a commercial company, fluid runs through hoses to cool a supercomputer in EMSL, a U.S. DOE national scientific user facility. This evaporative cooling technology is intended to reduce the supercomputer's heat load.

Getting Greener

Most renewable energy is still more expensive than traditional sources, but large consumers can help make it more widely available, driving down costs over time. PNNL is steadily increasing its renewable energy sources to diversify its supply, make better use of environmentally sound alternatives, and meet federal and state goals.

The main PNNL campus in Richland uses 12.3% "green" power from renewable sources including wind, small hydro, and biofuels. PNNL's Marine Research Operations on Washington coast's Olympic Peninsula is powered completely by electricity generated by recovered landfill gas. PNNL's purchasing commitment enables the city of Richland to buy a block of wind power from Bonneville Power Administration, some of which the city makes available to residents and businesses.

In 2006, PNNL began using biofuels containing part ethanol and biodiesel in its 28 fleet vehicles, as well as in boilers and backup generators in EMSL. PNNL's purchase commitment enabled the state's first public ethanol fueling station to open in Richland. Biofuel costs currently are comparable to those of petroleum-based fuel.

More Money

One way to stretch your energy management budget is to get others to pay for some of it. Over the last 11 years, PNNL brought in more than $13 million in alternative financing for energy programs.

As a U.S. DOE laboratory, PNNL uses federal energy savings performance contracts to borrow capital to hire private energy service companies to make building improvements. Project costs are paid back through energy savings.

The laboratory also received funding from the U.S. Department of Energy's Federal Energy Management Program to implement energy conservation measures such as lighting retrofits. Even nongovernment organizations can use cost-sharing approaches, like the motion-controlled power strips project mentioned earlier, in which the partners contribute an agreed-on combination of dollars, equipment, and labor.

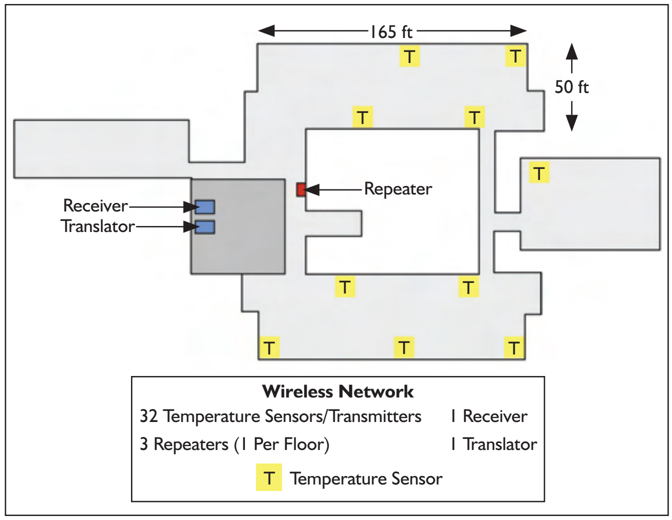

Figure 1: In-building wireless system—sensor layout, first floor.

Evaluating Effectiveness

In addition to analyzing energy reduction, cost avoidance, and payback times, PNNL uses the measurement system known

Name of Measurement	What It Measures	Building Rating for EMSL
Asset Condition Index	Current and projected future condition of an asset; measures effectiveness of maintenance management, including energy management.	0.99
Maintenance Investment Index	Planned maintenance as a percent of replacement plant value.	2.5%
Energy Reinvestment Index	A percent of annual, quarterly, or monthly avoided energy costs that was reinvested in another energy-saving technology.	5% ($50,000)

Table 1: Annual energy and operations evaluations for EMSL, a 200,000 ft² national scientific user facility.

as an Asset Condition Index (ACI) as part of its facility management evaluation, which includes energy-related maintenance. The ACI is a standard benchmark used in DOE facilities to assess the current and projected future condition of an asset. The measurement consists of this equation:

$$\text{ACI} = 1 - \left[\begin{array}{l} \text{cost avoided by deferred maintenance/} \\ \text{cost of the replacement value of the asset} \end{array} \right]$$

A result close to 1.0 indicates facilities are being maintained at their optimal point within a preplanned maintenance budget. The ACI scale ranges from “excellent” (1.0 to >0.98) to “failure” (<0.40). Each building has its own ACI.

Facilities managers at PNNL also use a risk-based life-cycle management approach. This shifts the focus from static or short-range condition assessments to life-cycle forecasting. PNNL uses industry standards and benchmarks for cost forecasting, combined with scenario planning. Decisions about energy-related upgrades are based on assessments by facilities managers and users about the importance of facility-specific missions combined with environmental, safety, health, and business risks.

Despite such tools, there’s little reliable historical data correlating maintenance costs, life expectancy, and plant replacement costs. This lack of data can result in underfunded annual maintenance and costly rehabilitation and repairs. Decisionmakers need reliable data to predict future cost and risk consequences of investment decisions over the expected facility life cycle.

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One way PNNL does this is with a Maintenance Investment Index (MII). An MII describes planned maintenance for facilities as a percent of their replacement plant value. The MII is:

Maintenance Investment Index = monthly actual costs/ replacement plant value

The maintenance investment index target is based on an industry standard of 2% to 4% of the replacement plant value to minimize the backlog of maintenance.

PNNL also uses a measure called an Energy Reinvestment Index. This is an investment of a percent of the annual, quarterly, and/or monthly energy cost of a facility toward future energy cost reductions. For example, if the energy reinvestment index goal is 10% for a particular year, with a $5 million annual energy cost, $500,000 would need to be invested in other energy-savings projects. It's important to show a return on that $500,000 investment.

Table 1 shows an example in which three of these measurements were applied to the building known as EMSL, described earlier.

Conclusions

Managing building energy use requires a strategic, across-the-board program that goes beyond installing energy-efficient equipment and meeting code requirements. A successful program includes physical upgrades, occupant behavior change, appropriate use of renewable energy, and partnering with others to fund energy efficiency initiatives. A variety of outcome measures, including those that balance asset condition with the maintenance budget, help managers better plan energy upgrades as part of facility operations.

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