Municipal Energy Management

Best Practices from DVRPC's Direct Technical Assistance Program

APRIL 2016

DELAWARE VALLEY REGIONAL PLANNING COMMISSION

The Delaware Valley Regional Planning Commission is dedicated to uniting the region's elected officials, planning professionals, and the public with a common vision of making a great region even greater. Shaping the way we live, work, and play, DVRPC builds consensus on improving transportation, promoting smart growth, protecting the environment, and enhancing the economy. We serve a diverse region of nine counties: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey. DVRPC is the federally designated Metropolitan Planning Organization for the Greater Philadelphia Region — leading the way to a better future.

The symbol in our logo is adapted from the official DVRPC seal and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. The authors, however, are solely responsible for the findings and conclusions herein, which may not represent the official views or policies of the funding agencies.

DVRPC fully complies with Title VI of the Civil Rights Act of 1964 and related statutes and regulations in all programs and activities. DVRPC's website (www.dvrpc.org) may be translated into multiple languages. Publications and other public documents can be made available in alternative languages and formats, if requested. For more information, please call (215) 238-2871.

Acknowledgments

Assistance on development of best practices, provision of data, and the drafting of this report was provided by a team at Practical Energy Solutions led by Dianne Herrin.

The municipalities that participated in *Direct Technical Assistance* contributed time and knowledge to the creation of this report through their participation in the *Direct Technical Assistance* program. Those municipalities include Bristol Township of Bucks County; Easttown Township and Phoenixville Borough of Chester County; Lansdowne Borough, Nether Providence, and Upper Darby Township of Delaware County; and Cheltenham Township, Horsham Township, and Towamencin Township of Montgomery County.

Table of Contents

Acknowledgments ii
Executive Summary 1
Tech Support: The Value of Professional Experts 2
Energy Management Best Practices for Municipal Facilities
- **Best Practice #1: Track and Benchmark Energy Use and Costs** 4
- **Best Practice #2: Stop Deferring HVAC Maintenance** 7
- **Best Practice #3: Isolate the Source of Comfort Issues** 8
- **Best Practice #4: Multiple Energy Projects? Consider a Whole Building Approach** 10
- **Best Practice #5: Upgrade Lighting At Once** 11
- **Best Practice #6: Plan for Replacements** 14
- **Best Practice #7: View Window Projects as Facility Investments** 16
- **Best Practice #8: Don't Rule Out Energy Savings Just Because A Building is New** 18

Tips for Implementing Energy Management Opportunities 19

Tables

Table 1: Sample ENERGY STAR Portfolio Manager Tracking/Benchmarking Overview for Local Borough Hall/Police Department 5
Table 2: Example HVAC maintenance savings 8
Table 3: Phased vs One-Time Lighting Upgrade in Administration Building with 302 T12 Fluorescent Fixtures: Savings Over 5 Years 11
Table 4: Lighting Project Savings: DTA Municipalities 11
Table 5: Table 6 HVAC Equipment Inventory for an Administration/Police Facility 15
Table 6: Recommended Efficiency Ratings for Replacement Units 15
Table 7: High-Efficiency Unit Savings 15
Table 8: Window Replacement/Upgrade Options 16

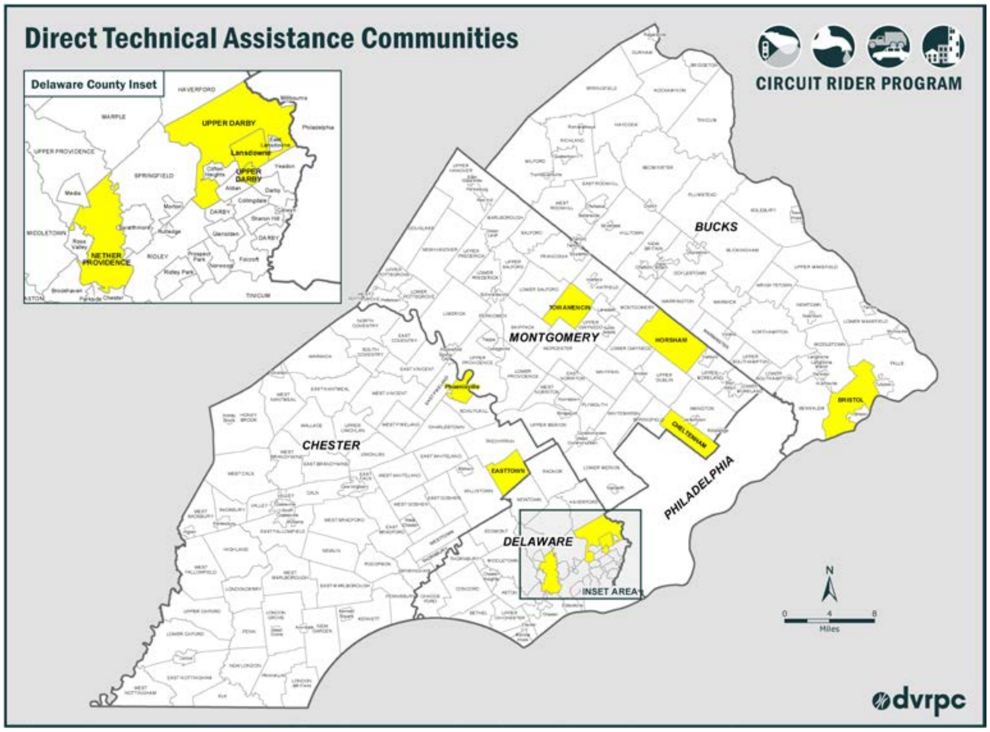
Figures

Figure 1: Direct Technical Assistance Communities 1
Figure 2: Benchmarks (EUIs) for Administration/Police Department Facilities in Southeastern PA 5
Figure 3: Energy Bill vs. HVAC Repair Bill 6
Figure 4: Pump Stations Estimated Energy Cost 6
Figure 5: Selected Pump Station Energy Costs (11 mos., 2011-2012) 6
Figure 6: Average Energy End Uses for Police/Administration Buildings 7
Figure 7: Air infiltration shown with infrared camera (right image) 9
Figure 8: Nonfunctional Baseboard Thermostat in Municipal Administration Building 9
Figure 9: Sequential Reduction of Energy Demand Reduces Boiler Size 10
Figure 10: Impact of Efficiency (SEER Rating) on Annual Energy Costs 14
Figure 11: Municipal Building with 25 Percent Window Fenestration 16
Figure 12: Average Energy End Uses for Police/Admin Buildings 17
Figure 13: Police Facility Energy Use Intensity Scores 18

Executive Summary

This guide for municipal officials highlights best practices and lessons learned from municipal energy management projects in southeastern Pennsylvania. In 2013 and 2014, DVRPC worked with nine municipalities in southeastern Pennsylvania to provide direct technical assistance with measuring, analyzing, and developing implementation strategies for energy management in municipal buildings. DVRPC selected municipalities through a competitive application process designed to determine commitment, need, and opportunity. The municipalities selected represent the diversity of municipalities across southeastern Pennsylvania, as shown in Figure 1 below.

Figure 1: Direct Technical Assistance Communities



Source: DVRPC 2014

This work was conducted under DVRPC's *Circuit Rider for Energy Efficiency in Local Government Operations* program, funded by the U.S. EPA. DVRPC hired a technical consultant—Practical Energy Solutions (PES)—to assist with scoping and prioritizing projects, conducting energy assessments, and working with municipalities to incorporate energy management recommendations through the municipal decision-making process. DVRPC selected PES as a trusted and qualified energy expert that was able to provide unbiased expertise and clear communication on energy management to municipalities in the program.

DVRPC and PES followed a step-wise approach with these nine municipalities that included the following steps:

1. Gathered and analyzed utility bills;
2. Met one-on-one to review utility bill analysis and prioritize energy management goals and needs;
3. Conducted energy assessments of highest-priority buildings;
4. Met one-on-one to deliver energy assessments and refine recommendations; and
5. Worked with municipalities to identify strategies to implement selected measures.

Context of municipal energy planning

There are more than 230 municipalities in southeastern Pennsylvania that, in addition to providing the services and day-to-day operations for residents and business, must manage facilities of their own. Typically, these facilities are all candidates for energy management, which when implemented can save the municipality energy and money, and improve comfort for occupants of the building. Yet municipalities are frequently understaffed and cash-strapped, making the ability to identify and implement energy management decisions at these facilities a challenge.

The goal of energy management is to identify opportunities for improving how energy is being used at your facilities and to feel confident in making a decision on how best to prioritize and implement these improvements. These improvements can remedy various problems—high energy and maintenance costs due to malfunctioning equipment; poorly installed or aging equipment; poor occupant comfort due to a lack of weatherization; or poorly controlled equipment.

This guide will illustrate several best practices for identifying and implementing energy management opportunities that save money and improve building comfort. This guide will help you understand how to answer the following questions about the energy management process.

- How do I know that I have energy management opportunities at my facility and where do I start?
- What energy management decisions will be most effective in the long run?
- Once I've decided on the right course of action, who can help me get it implemented? Whom should I trust?
- How can I justify the upfront expense and convince the decision-making body in my community that this is the right decision to make?
- Are there any low- or no-cost measures that we can implement now?
- How do I track the progress of implementing these measures?

The ability to answer these questions provides a long-lasting and important foundation toward institutionalizing energy management in your facilities and pursuing broader energy and climate goals in your community. Municipalities set the stage—in practice and in policy—for their residents and businesses to achieve similar energy management goals. When achieved, these practices have long-lasting financial and environmental benefits for the whole community.

Tech Support: The Value of Professional Experts

All municipalities, even those with knowledgeable facilities staff, will benefit from the services provided by a technical expert in building energy management. A technical consultant will be able to analyze utility bills, conduct an energy assessment of your facilities, and provide unbiased guidance on identifying and implementing energy improvement opportunities. Typically, the consultants will identify savings that far exceed the cost of their services. The following is a list of what to expect when working with a technical consultant:

- **Utility Bill Analysis:** Before conducting an assessment of your facilities, a technical consultant will need to access information about the facilities that you are interested in evaluating—such as square footage, year built, and utility bills (typically two years' worth is ideal)—and do their own benchmarking and analysis of data. Municipalities can also tackle benchmarking in-house as a first step before hiring a consultant (this is recommended to become familiar with the data). For more information, see *Best Practice #1: Track and Benchmark Energy Use and Costs*.

- **Scoping the Project:** Municipalities should request a one-on-one meeting with the technical consultant before the energy assessment is conducted to cover the following:
    - Review the findings of the utility bill analysis: annual energy expenditures by building, building energy metrics, current cost per unit of energy consumed, and additional significant findings.
    - Discuss additional building data needs to conduct an assessment (e.g., occupancy schedules, model and age of equipment), as needed.
    - Communicate anecdotal information about the building, such as frequent maintenance, lack of comfort in a particular area of the building, or presence of aging equipment.
    - Finalize a list of what your consultant will assess in each building.
- **Energy Assessments:** An energy assessment will typically take 1.5 to three hours per building, depending on its size, use, and complexity. It is recommended that a facility or grounds manager be present during the assessment so that your consultant can access locked areas (e.g., rooftops, boiler rooms, air handler units, Building Automated System (BAS), etc.) and ask questions about systems and the building(s). The elements of an energy assessment can include:
    - Inventory of lighting, HVAC (heating, ventilation, air conditioning) systems, pumps, and plug loads, including computers, printers, and faxes. It also may include counting lights, recording HVAC make/model numbers, taking photographs, and conducting general inspections of equipment functionality.
    - Evaluation of HVAC control systems, including recording of all thermostatic setpoint schedules and assessing BAS system information/data.
    - Assessment of ventilation by recording CO_2 levels throughout the building.
    - Recording light levels in all relevant areas to detect over- or under-lighting.
    - General inspection of the building construction and envelope (including windows, thermal breaks, and any areas of moisture), potentially using thermographic equipment and other tools.

Municipalities that have a dedicated facilities staff person who is familiar with the building systems and can work with the consultant and follow through with implementation may be at an advantage, though municipalities without dedicated staff can benefit too. For all municipalities, don’t hesitate to have your technical consultant talk directly with your contracted maintenance staff about persistent maintenance issues and general system functionality.

Energy Management Best Practices for Municipal Facilities

Best Practice #1: Track and Benchmark Energy Use and Costs

Once a municipality makes a commitment to manage energy at its facilities, tracking energy use and cost is the first and most important step. Tracking reveals anomalies in energy use caused by malfunctioning and declining equipment, and therefore identifies where there may be opportunities for energy management. Problems associated with malfunctioning and declining equipment can be expensive if they go undetected. Tracking also shows how your actions—like changes in building uses, operating hours, HVAC equipment, lighting systems, or thermostat settings—impact consumption and utility costs. Most importantly, tracking reveals longer-term consumption and cost trends, so you can manage your energy use over time.

You can track utility consumption and costs by benchmarking. Benchmarking is the process of converting energy use data into energy performance metrics—tracked for a given period of time for a single building or multiple buildings—and comparing that information to the performance of similar buildings of the same type. Benchmarking allows you to identify areas where the building is performing poorly—areas where opportunities for energy savings exist.

Municipalities are encouraged to benchmark their buildings using the free on-line ENERGY STAR Portfolio Manager tool. This easy to understand tool developed by the US Environmental Protection Agency allows users to follow simple steps to enter their building characteristics into the tool—for a single building or for all buildings managed by the municipality. Once your buildings are set up in the tool, it's a simple matter of inputting cost and use data from the utility bill. To learn how to get started, see DVRPC's how-to *Portfolio Manager Guide for Municipalities.*[1]

Energy Use Intensity (EUI)

Energy Use Intensity—measured as kBtu/square foot—is a commonly used measure for benchmarking whole-building energy performance. In order to determine a building's EUI, all energy consumption for a facility (e.g., electricity, natural gas, delivered fuels) is converted to a common metric of British Thermal Units (Btus), usually expressed in kBtu (1000s of Btus). Building square footage, uses, and local climate are three factors that are typically used to normalize total energy consumption across multiple buildings and allow for fair comparisons.

Once you have a full year's worth of data in Portfolio Manager, the tool will compare your facilities' energy performance with that of other, similar buildings. The Portfolio Manager system will do this automatically by converting energy use data into whole-building energy performance metrics and comparing your metrics with those of similar buildings. The most significant metric is the energy use intensity (EUI), measured as kBtu per square foot (see box). Just as high utility bills suggest opportunities for cost savings, high EUIs suggest opportunities for energy savings. Table 1, below, shows how EUI can impact energy costs, energy use, and greenhouse gas (GHG) emissions.

The overview shown in Table 1, generated by Portfolio Manager, shows a 35 percent cost savings and a 34 percent reduction in energy use intensity since April 2011 due to energy management investments and changes made at the facility. The ENERGY STAR score of 34 shows that the facility's energy performance is better than 34 percent of similar buildings, but inferior to 66 percent—suggesting that there are further opportunities to save energy and cut utility costs.

---

[1] *Portfolio Manager Guide for Municipalities:* http://www.dvrpc.org/EnergyClimate/CircuitRider/pdf/PortfolioManagerGuide.pdf

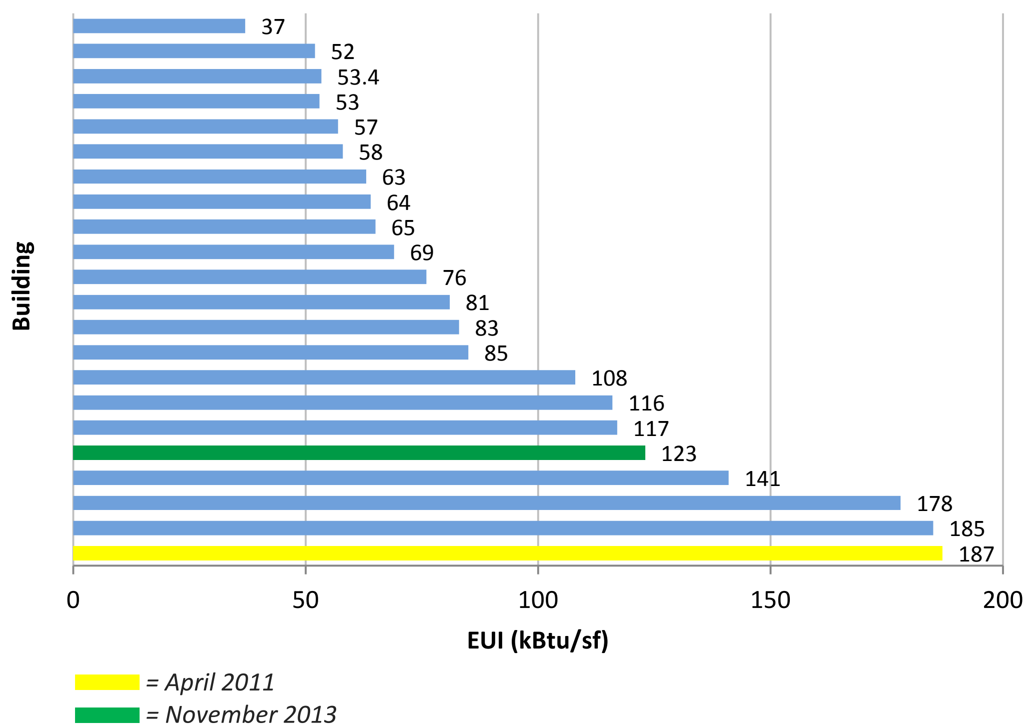
Table 1: Sample ENERGY STAR Portfolio Manager Tracking/Benchmarking Overview for Local Borough Hall/Police Department

Metric	Baseline (Apr 2011)	After Investment (Nov 2013)	Target	Median Property
ENERGY STAR score (1—100)	9	34	75	50
Site EUI (kBtu/ft²)	187.7	123.1	77.1	104.3
Site Energy Use (kBtu)	2,003,940.7	1,314,232.2	823,166.5	1,113,298.2
Energy Cost ($)	$38,314.56	$24,868.46	$15,575.62	$21,066.30
Total GHG Emissions (Metric Tons CO2e)	158.1	106.1	66.5	89.9

Source: Practical Energy Solutions 2014

For the Direct Technical Assistance program, DVRPC and PES benchmarked the participating municipalities' facilities to gauge the potential for energy management opportunities. Figure 2 shows a dataset of EUIs for 21 Administration/Police facilities in southeastern Pennsylvania. This dataset allows us to compare one administration/police building's EUI to others within in the same geographic area. The yellow bar represents the 2011 EUI for the Lansdowne administration/police facility in Delaware County; the green bar represents the same facility's improved EUI 2.5 years later after a series of lighting and HVAC upgrades. The energy assessment identified further energy management opportunities for this municipality, which will continue to reduce its EUI, utility costs, and environmental footprint. For a complete overview of this project, see the Lansdowne Borough Hall Case Study[2].

Figure 2: Benchmarks (EUIs) for Administration/Police Department Facilities in Southeastern PA



Source: Practical Energy Solutions for DVRPC 2014

[2] Lansdowne Borough Hall Case Study: http://www.dvrpc.org/Products/15024F/

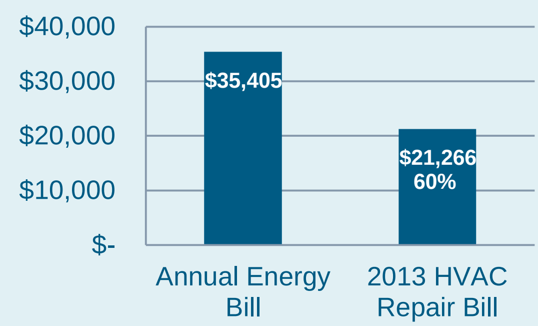
Track Maintenance Costs, Too

Too often, municipalities maintain HVAC systems reactively—that is, when something breaks, the HVAC contractor comes in to fix it. While these situations aren't entirely avoidable, especially when systems are aging, reactive maintenance can contribute to high maintenance costs, high energy use, and discomfort due to poor temperature control.

To determine if your maintenance costs are too high, track them in relation to your annual utility costs. Energy costs typically make up the majority of operating expenses for an HVAC system, but when municipalities begin to see that maintenance costs are making up a significant portion of operating expenses, an investigation into repairs and improvements into that equipment should be made. In one municipality investigated through this program, maintenance costs were 60 percent of energy costs. When the benchmark showed that this same facility also had a high EUI (102 kBtu per square foot), it became clear that the key to effective energy management in this facility needed to start with identifying the underlying HVAC system performance issues.

It also helps to prioritize preventive HVAC maintenance in the budget by not treating it as an overhead cost that is easily subject to budget cuts. Municipalities should include money in their budget for preventative maintenance every year—a system that receives proper maintenance every year will last longer, run more efficiently, and cost less in the long run.

Figure 3: Energy Bill vs. HVAC Repair Bill

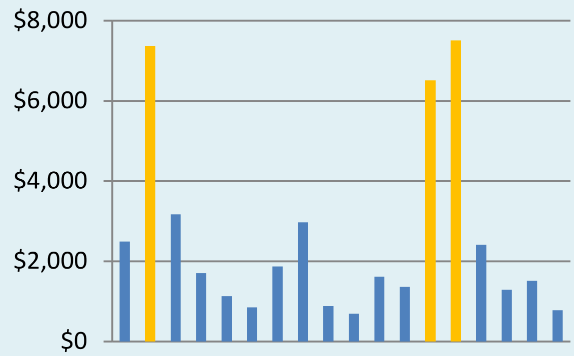


Source: Practical Energy Solutions for DVRPC 2014

Tracking Reveals Easy to Fix Pump Station Problem

For one municipality with multiple pump stations, energy cost tracking quickly revealed an anomaly that was easy to address, saved the township $3,600 annually, and paid back in less than one year. When we graphed the annual energy costs for all of the township's pump stations, as shown in Figure 4 below, we quickly saw that three facilities had unusually high costs (highlighted in yellow).

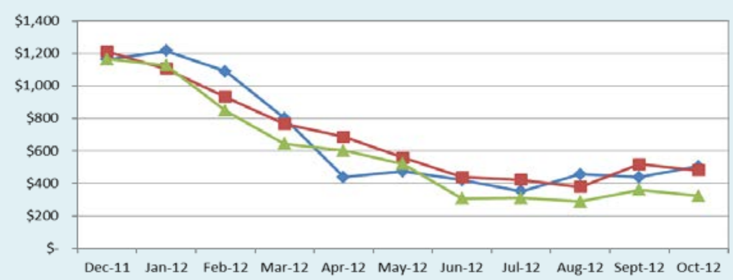
Figure 4: Pump Stations Estimated Energy Cost



Source: Practical Energy Solutions for DVRPC 2014

A look at the monthly energy costs for these three pump stations, Figure 5, showed that the wintertime energy costs were almost 75 percent higher than summer costs.

Figure 5: Selected Pump Station Energy Costs (11 mos., 2011-2012)



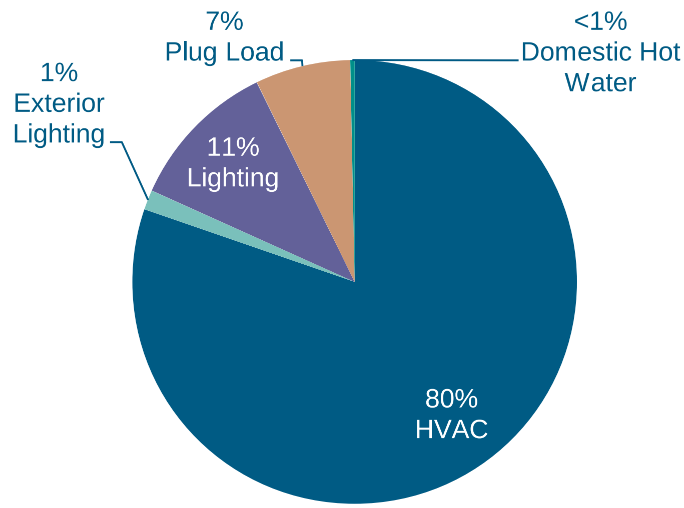
Source: Practical Energy Solutions for DVRPC 2014

A quick visit to one of the stations on a cold February day revealed that the indoor temperature was 75°F and unit heaters were running despite a 60°F thermostat setting. By replacing broken thermostats in these three pump stations, the township is expected to save $3,600 annually, with a payback in a matter of months. This initial (and easy) analysis of the pump station utility bills allowed PES to identify this simple and cost-saving energy-management opportunity.

Best Practice #2: Stop Deferring HVAC Maintenance

As shown in Figure 6, HVAC systems typically account for the majority of energy use in municipal buildings. Keeping HVAC systems running properly and at peak efficiency is critical to managing energy use. Depending on the condition and type of HVAC system, effective maintenance can reduce HVAC energy costs an average of 15 to 20 percent (range: five to 40 percent), while also cutting maintenance expenses.

Figure 6: Average Energy End Uses for Police/Administration Buildings



Source: DVRPC 2014

This is because systems that are malfunctioning, uncontrolled, dirty, or deteriorating tend to run overtime to try to reach temperature setpoints. For example, an air damper that is stuck open can increase energy use 15 to 40 percent because it brings too much outside air into the building—causing the system to work overtime to heat cold air in winter or cool too much hot, humid air in summer. Even a dirty air filter will increase energy use by five to 15 percent by blocking air flow.

To help municipalities address deferred maintenance issues and greatly improve efficiencies, DVRPC's consultant, PES, began with a high-level energy evaluation to create a list of system and comfort issues identified by building occupants. When the municipality had a relationship with a reliable contractor who demonstrated a working knowledge of the facility, PES collaborated with the contractor to gain a full understanding of the issues, obtain cost estimates for necessary work, calculate energy savings, and recommend the best course of action. With solid cost proposals in hand, it is relatively easy to determine the return on investment (ROI) for maintenance projects and prioritize a plan based on the anticipated energy savings, budget, and future building uses.

Table 2, below, shows an example from the program—an aging civic center with a steam heating system. Steam systems are prone to maintenance problems and are difficult to maintain, and this case was no different from many others. Uninsulated piping and insufficient thermostatic control caused energy waste equivalent to 20 percent of the facility's fuel oil bill. Since long-term plans for the building were uncertain, PES sought short-term opportunities to reduce energy waste and improve comfort—including insulating the steam piping and installing controls on the steam radiators to prevent runaway heating.

In this civic center, the oil storage tank and pump were deteriorating. This presented an opportunity to switch the duel-fuel boiler to natural gas, cut the heating bill by an additional 50 percent, and provide budgetary savings needed to fund the identified deferred maintenance tasks at the Civic Center, as shown in Table 2. The end result is a 70 percent heating bill reduction.

For a complete overview of this project, see the *Phoenixville Civic Center Assessment Report*[3].

Table 2: Example HVAC maintenance savings

Deferred Maintenance Task	Annual Cost Savings	Project Cost	Simple Payback
Install thermostatic radiator valves on steam system	$1,390	$4,531	3.3 years
Insulate steam pipes	$1,250*	$4,842	3.8 years
Convert dual-fuel boiler to natural gas to address failing underground oil storage tank/pump	$7,204	$4,980	<1 year
AGGREGATED SAVINGS/PAYBACK	**$8,594**	**$14,353**	**1.7 years**

Notes: *Includes natural gas savings and annualized cost of avoided pipe repairs.
Source: Practical Energy Solutions 2014

Tips for Hiring a Trusted HVAC Contractor

A good plan to address deferred maintenance starts with someone you can trust. While many HVAC contractors are well-intentioned, they don't all have the expertise and ability to take a holistic view of your HVAC systems and create a deferred maintenance plan. Consider these tips for ensuring that your contractor is right for the job:

It can be done. If your contractor easily dismisses your request and says that it can't be done, be suspicious. Look for someone who duly considers the problems at your facility and takes the time to put some thought into it.

There are usually alternatives. If your contractor has one immediate solution and can't provide alternatives, this can be a sign that he or she is unwilling to do the up-front work necessary to consider all options.

The contractor should have relatable experience. Can the contractor provide examples of how he or she has approached similar problems in other facilities? If not, your job may represent uncharted territory.

Demand a clear rationale. If the contractor can't explain the core reason(s) for the problems you're experiencing, or your high maintenance costs, this may reflect a lack of understanding.

Best Practice #3: Isolate the Source of Comfort Issues

Comfort issues are common in aging buildings and, over time, can cost a municipality in lost productivity and high energy costs. They typically result from two conditions:

1. Lack of HVAC control, which can have many root causes, such as malfunctioning thermostats or sensors, mechanical disrepair, insufficient balancing/zoning, leaking ducts, and more.
2. Breaks in the building envelope, which often occur because people occupy spaces not originally intended for occupancy, and because of rehabs, additions or other facility changes, unsealed windows, or construction methods that did not prioritize energy efficiency. These breaks can be small, but when added up, they introduce a lot of outside air into the building. Figure 7, below, shows an image captured by an infrared camera showing significant air

[3] Phoenixville Energy Assessment: http://www.dvrpc.org/Products/15024H/

infiltration, indicated by a significant temperature differential (ranging from 67°F to 76°F) that caused comfort issues for occupants of this building.

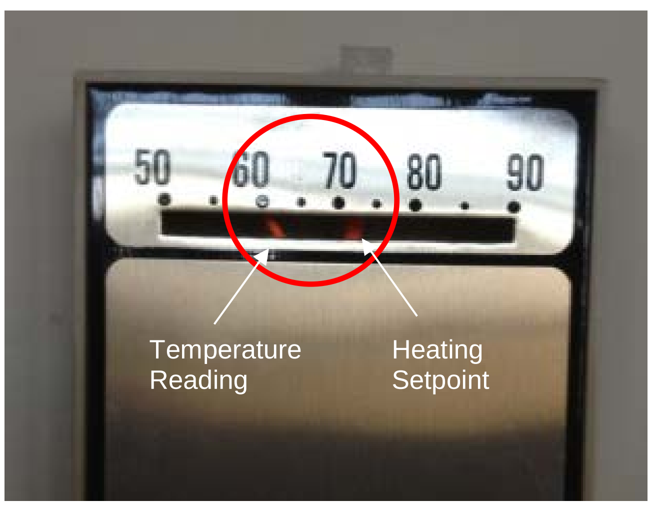
Treating comfort issues without addressing the source of the problem only increases energy use and utility expenses. Space heaters, for example, worsen temperature imbalances and can cause electricity costs to increase. Further, constant adjustment of thermostats and setpoints, manual adjustment of outside air dampers, and taping over air vents can cause systems to struggle and work overtime, further increasing utility expenses and exacerbating comfort problems.

Figure 7: Air infiltration shown with infrared camera (right image)

Source: Practical Energy Solutions for DVRPC 2014

The energy consultations provided by PES through DVRPC's program helped municipalities target the sources of comfort issues. For example, in one municipal administration building with central hot-water coil air handlers and perimeter hot-water baseboards, PES found that the baseboard thermostats were not working, as shown in Figure 8. This was causing the baseboard heat to be permanently on in some areas and off in others. Employees' use of space heaters worsened temperature imbalances by raising the temperature in some areas, thereby preventing the central heating system from kicking on. The resulting energy waste represented an estimated 12 percent of this municipality's annual utility costs.

Figure 8: Nonfunctional Baseboard Thermostat in Municipal Administration Building



Source: Practical Energy Solutions for DVRPC 2014

To address the problem, PES recommended a three-step plan for the municipalty's HVAC contractor to fix the lack of control:

1. Evaluate/repair all defective thermostats, sensors, actuators, and other components;
2. Replace all manual thermostats with digital, programmable thermostats with locking covers; and
3. Schedule all thermostats so the baseboards provide supplementary heat on cold days and in the mornings, as needed.

This project is expected to cut total utility costs 12 percent and pay back in four years or less. For more details on this project, see the *Towamencin Township Energy Assessment.*[4]

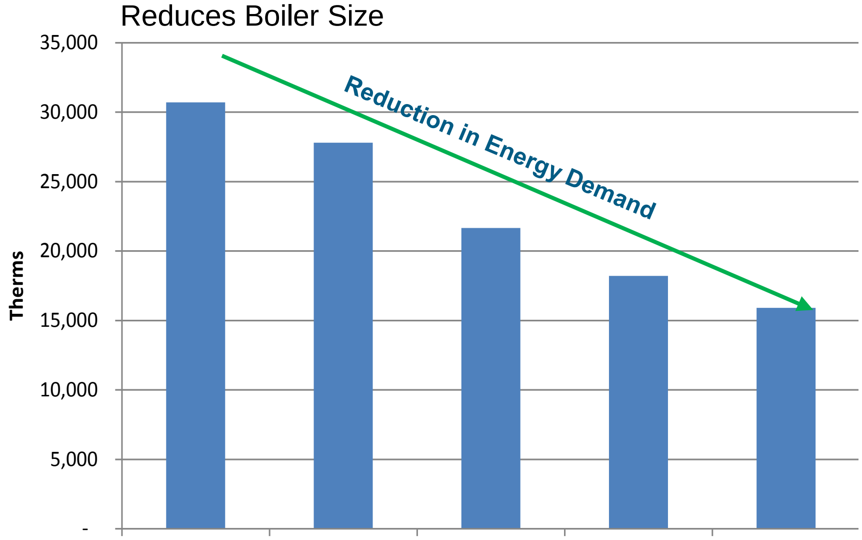
Best Practice #4: Multiple Energy Projects? Consider a Whole Building Approach

Given the human and financial resource challenges faced by municipal governments, it's common to take on energy projects as you are able to fit them in. Taking an unplanned approach, however, can be costly if you have multiple projects that need attention. Instead, take a small step back and view all of your facility needs holistically, and determine the sequence in which they should be implemented. This whole-building approach will enable you to prioritize projects, justify them financially, and proceed in the most cost-effective way.

For example, a facility that needs a new boiler will benefit from eliminating heating system inefficiencies before purchasing the new boiler. This is because improving efficiencies reduces energy demand, and thereby allows the purchase of a smaller "right-sized" boiler. The smaller boiler will cost less to buy and, over its 20 year (or more) life span, will use less fuel and cost less to operate.

Figure 9 shows the ideal project sequence for one municipality that participated in *Direct Technical Assistance* for its 45,034 square-foot administration building. The facility was in need of lighting upgrades, new windows, steam system renovations, and new thermostats, as well as a new boiler. By sizing the boiler for the new base load, this municipality will save an additional 16 percent on its heating bill and reduce equipment costs. For a full overview of this project, see the *Upper Darby Municipal Building Case Study.*[5]

Figure 9: Sequential Reduction of Energy Demand Reduces Boiler Size



Source: Practical Energy for DVRPC Solutions 2014

[4] Towamencin Energy Assessment: http://www.dvrpc.org/Products/15024I/
[5] Upper Darby Energy Assessment: http://www.dvrpc.org/Products/15024J/

Best Practice #5: Upgrade Lighting At Once

It's well known that it makes great financial sense to upgrade old, inefficient lighting systems. The savings are significant, and the payback is short. It's not well known, however, that taking the project too slowly (installing new lights in small areas over a long period of time) can cost the municipality money. While, for some municipalities, it may seem like the only path forward is to install new lights in a piecemeal fashion as resources are available, municipalities that find a way to borrow or shift resources in order to get the project done faster save more money. Table 3 shows the five-year savings from a lighting upgrade for a municipal administration building, where a conversion from T12 fluorescent lights to T8 fluorescent lights was being phased in slowly over time, and compares this with the five-year savings from an up-front upgrade. In this facility, the outmoded T12 fluorescent lighting wastes approximately $5,000 in excess energy costs each year.

The Importance of Working with a Qualified Lighting Expert:

Every lighting project is different, so it is recommended that municipalities consult with a qualified lighting expert to identify the appropriate lighting strategy for your facility. Municipalities should look for lighting consultants that are **independent** (they represent several—not just one—product lines and will attempt to sell you the best product that meets your needs), and they are **experienced.** Ask neighboring municipalities for recommendations—you want to identify a consultant that has done reliable work in the area.

Table 3: Phased vs One-Time Lighting Upgrade in Administration Building with 302 T12 Fluorescent Fixtures: Savings Over 5 Years

Project Phasing	Project Cost	Utility Savings 5 Years After Project Start (Over and Above Project Cost)
Phased in over 4 years	$14,314*	$ 4,008
One-time installation	$14,314	$11,861
Cost Difference	—	$7,853

Notes: *Phase-in cost may vary depending on year-to-year lamp and labor costs.
Source: Practical Energy Solutions for DVRPC 2014

Table 4 summarizes the estimated annual savings and payback periods for several lighting projects in administration/police buildings participating in this program. The average payback for these lighting projects was under three years.

Table 4: Lighting Project Savings: DTA Municipalities

Lighting Measure	Projected Annual Savings	Simple Payback
Lighting Upgrades	$5,235	2.7
4-lamp to 2-lamp conversion	$427	1.7
Selected fixture removal	$203	2.9
Install 28W T8s	$1,188	0
Improve Occupancy Sensors	$534	4.8
Install LED Exit Sensors	$235	6.4
Reduce Light Levels	$1,492	0-1.8
Lighting Upgrades (T12 to T8 or T5 conversion, 32W-28W replacement)	$7,408	3
		2.8 yr average payback

Source: Practical Energy Solutions 2014

T12 Lighting Retrofit Rules of Thumb

It was common for the municipalities participating in DVRPC's project to have outmoded, inefficient T12 lamps in their facilities. Municipalities are encouraged to replace T12 lamps with T8, T5, and, in some cases, LED lamps due to the energy-savings potential and quick payback. The T12 fixtures have also been phased out by the U.S. Department of Energy and are no longer commercially available, so the changeover is inevitable. A retrofit of T12 to T8 fluorescent fixtures is standard best practice and was the most common conversion for municipalities participating in *Direct Technical Assistance*. Below is a snapshot of the lighting retrofit rules of thumb for a T12 to T8 conversion developed by Practical Energy Solutions for this program:

- Replace T12 lamps with high-efficiency T8 lamps and new fixtures (17W for 24-inch T8 lamps, 28W for 48-inch lamps, and 86W for 96-inch high-output lamps).
- When replacing four-foot four-lamp T12 fixtures:
    - Replace lamps using a **2:1 ratio**. Replace four-lamp fixtures with high-efficiency, two-lamp four-foot 28W T8 fixtures. Many municipalities make the mistake of changing out bulbs in a 1:1 ratio. This is unnecessary, leads to over-lighting, and increases project expenses, as well as utility bills.
    - Consider light levels and decommission fixtures when your light levels are too high or you have too many fixtures. This adds to the energy savings.
    - Choose a fixture with white reflectors to direct light down into the room, enhancing light spread and output. White reflectors maximize output and minimize glare.
    - Buy new lenses with the new fixtures; using old, dirty lenses will compromise light quality and output.
    - Select a ballast with a low ballast factor to save energy and further reduce operational lighting costs.
    - Consider programmed start ballasts, which are more expensive than the standard "instant-start" ballasts, but they pay for themselves over time because they further reduce energy use and preserve bulb life, thereby reducing maintenance costs. Programmed start ballasts require a special lamp, as most T-8 lamps are designed for the instant start ballast.
- Replace remaining four-foot 32W fluorescent T8 lamps in existing fixtures with high-efficiency four-foot **28W** T8 lamps as your bulbs burn out. This will reduce lamp inventory to one type of four-foot T8 bulb and further reduce energy use without compromising light output.

Delamping Can Save Big

In one municipality, light levels were found to be two to four times higher than the industry-recommended standard for the space. To address this, PES recommended a combination upgrade and delamping strategy, which will reduce lighting electricity use by more than two-thirds in the facility, reduce the total number of fluorescent lamps in the building by approximately 49 percent. It will also save an additional $225 per year in avoided lamp replacement costs and help free up facilities' staff time. In total, the delamping and upgrade strategy will save the municipality $7,400 in energy costs annually.

Advanced Lighting Technology: The Battle between Fluorescent and LED Technologies

The Circuit Rider Program experience offers confirmation that lighting upgrades are a great place to start when it comes to energy-efficiency improvements. The savings can be great, payback times are often short, and the outcome often adds up to superior lighting output and quality—not to mention an improved working environment.

The challenge comes in deciding what type of lighting system to install. The best choices for office environments are new-generation T8 fluorescent tubes and LEDs, but it's becoming harder and harder to decide between the two technologies. Many municipalities are interested in the improved lighting quality and long lifespan of LED technology compared to standard florescent technology. However, because LEDs cost substantially more thanT8s— but last longer—they were often reserved for high-bay applications and other hard-to-reach areas, where lamp replacement is difficult. Recently, however, LEDs for interior office spaces have become more competitively priced with T8 systems, so installation costs are less of a concern.

Simultaneously, T8 technology has improved, and some T8 fluorescent tubes are now rated to last as long as LEDs (70,000 hours). What's more, new "super T8" technology has resulted in higher lumen output per watt, allowing further energy savings with fluorescent systems, especially when combined with high-efficiency ballasts and high-quality reflectors that further maximize light output without increasing energy consumption.

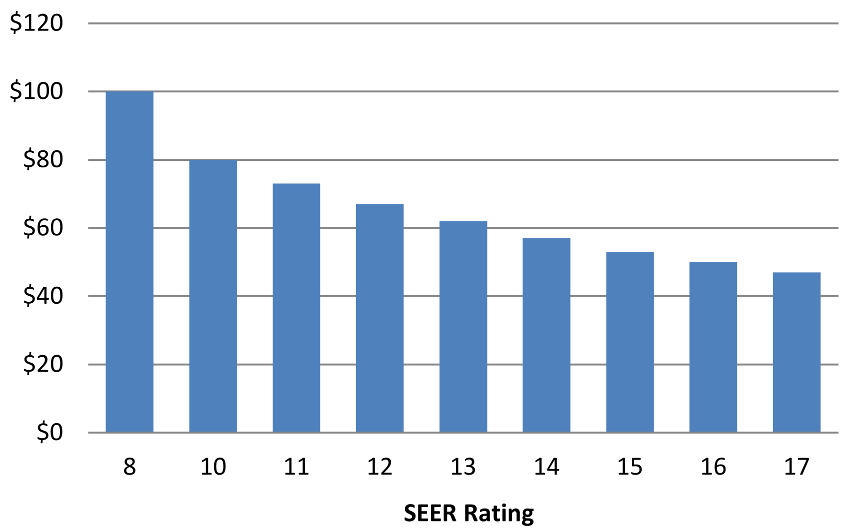
Still, a primary remaining difference between the two technologies is energy consumption. LEDs continue to use less energy than T8 tubes per unit of useful light output and are therefore the most energy-efficient lighting technology available. As a result, LEDs will save more on the utility bill over time.

Municipalities that still have T12 fluorescent or first-generation T8 lamps in operation are almost sure to benefit financially from an upgrade to new-generation T8s or LED systems. The best way to determine which technology and system will work best for you is to consult a qualified lighting specialist and consider a pilot installation. A trial will help determine the best lighting system for your needs while maximizing financial and environmental savings.

Best Practice #6: Plan for Replacements

Replacing HVAC equipment is a costly and often daunting prospect for municipalities. Yet all municipalities have to face this task eventually. Making a purchasing decision for HVAC equipment *after* existing equipment fails will cost more money—both in first costs and for the duration of the equipment life—than planning in advance. Emergency purchases carry a premium and, typically, only standard-efficiency equipment is available off-the-shelf. As a result, municipalities end up paying a premium price for standard-efficiency replacement units, which will increase the municipality's utility costs for 15 to 25 years. Figure 10 below shows how a higher efficiency rating results in lower annual energy costs.

Figure 10: Impact of Efficiency (SEER Rating) on Annual Energy Costs



Notes: SEER = Seasonal Energy Efficiency Ratio. SEER measures air conditioning and heat pump cooling efficiency. A higher SEER rating indicates greater energy efficiency. Hypothetical scenario set at a $100 baseline, for illustrative purposes.
Source: Practical Energy Solutions 2014

Rather, you can plan for HVAC equipment years in advance of having to make the purchase. This allows you to budget properly for the investment. PES recommended the development of a high-efficiency HVAC replacement plan for several municipalities interested in replacing equipment, or who were using equipment that was failing or approaching the end of service life. A thoughtful HVAC replacement plan will ensure that the municipality is prepared to purchase equipment that produces the best energy and cost savings over time.

An HVAC replacement plan starts with an inventory of existing equipment. Future use of the building must then be considered, since changes in use and additions or renovations will impact the type and size of equipment you need. For municipalities in need of whole-system replacements, it also helps to obtain an energy assessment so you can determine your best path forward. Often, the need for a system-wide replacement presents an opportunity to upgrade to a new type of system and/or right size oversized equipment—both of which will significantly reduce utility costs. A timeline and budget should be developed so you have the resources needed to make a smooth transition—and a smart purchase. One municipality noted that larger purchases, such as HVAC equipment, are typically introduced to the budget process five years before they will need to be purchased in order to give the municipality time to prioritize funding for the measure in time to replace equipment before it catastrophically fails. Lastly, as indicated in Best Practice #4, the replacement plan should take place as part of a stepwise approach toward whole-building energy management to ensure that the systems are right-sized to ensure maximum efficiency.

Table 5 shows an HVAC equipment inventory for a 10,200-square-foot administration and police facility. While all units are functional and in fair condition, they are nearing the end of their service lives, making a replacement plan important.

Table 5: HVAC Equipment Inventory for an Administration/Police Facility

Description	Serves	Make/Model	Year	Cooling Capacity [Btuh]	Cooling Efficiency [EER]	Heating Capacity [Btuh]	Heating Efficiency [AFUE]
Gas Furnace	Lower/1st Levels	Lennox G26Q4/5-100	1995			93,000	92.0%
Gas Furnace	Lower/1st Levels	Lennox G26Q4/5-100	1995			93,000	92.0%
Gas Furnace	Lower/1st Levels	Lennox G26Q4/5-100	1995			93,000	92.0%
Gas Furnace	Lower/1st Levels	Lennox G26Q4/5-100	1995			93,000	92.0%
Gas Duct Heater	Council Mtg (2nd Level)	Trane GDA 580A	1970s			64,000	70.0%
Gas Duct Heater	Council Mtg (2nd Level)	Trane GDA 580A	1970s			64,000	70.0%
Electric Spc Htr	Individuals	Various	n/a			5	
Split System CU	Lower/1st Levels	Lennox HS29-513-1Y	1995	48,000	*9.0*		
Split System CU	Lower/1st Levels	Lennox HS29-513-1Y	1995	48,000	*9.0*		
Split System CU	Lower/1st Levels	Lennox HS29-653-1Y	1995	60,000	*9.0*		
Split System CU	Lower/1st Levels	York E2RA048S25G	1996	48,000	*9.0*		
Split System CU	Council Mtg (2nd Level)	York H3RA060S06G	1994	60,000	*9.0*		
Split System CU	Council Mtg (2nd Level)	York H3RA060S06B	2004	60,000	*9.0*		

Source: Practical Energy Solutions for DVRPC 2014

When looking at HVAC replacement, you want to look at the whole system to see if it makes sense to redesign, though in some cases, a one-to-one replacement is possible. In this facility, there was no need to perform a wholesale system redesign, and the unit sizing was correct. In this case, PES simply recommended more efficient replacement units. Table 6 shows the recommended efficiency ratings for the replacement units, and Table 7 shows the savings associated with purchasing high-efficiency units. When comparing the savings, it's important to distinguish between the cost of the unit and the premium cost for the high-efficiency model. Since the investment is a necessary one, this differentiation helps municipalities see how quickly the premium cost will pay off, as shown in Table 7.

Table 6: Recommended Efficiency Ratings for Replacement Units

Item	Efficiency: Existing	Efficiency: New*
Outdoor DX Condensing Unit	9 EER	≥ 12 EER
Natural Gas Furnace	70% E_t	≥ 92% E_t
Natural Gas Duct Heater	92% E_t	≥ 90% E_c

Notes: EER = Energy Efficiency Ratio. E_t = Thermal Efficiency. E_c = Combustion Efficiency. *ASHRAE 189.1—2011. Use most current high-efficiency standards at time of purchase.
Source: Practical Energy Solutions for DVRPC 2014

Table 7: High-Efficiency Unit Savings

Measure Description	Annual Energy Savings	CO_2 Savings (lbs)	Energy Cost Savings [$/yr]	Estimated Premium Cost*	Simple Payback [yrs]	Savings Over 15 Years
High-efficiency HVAC	7,771 kWh	9,791	$ 1,060	$ 3,077	2.9	$36,924
	168 ccf	2,021				

Notes: Payback is based on the premium cost, or cost difference between standard-efficiency and high-efficiency units, as these units will need to be replaced anyway. Savings based on current energy rates. Savings will change as energy prices change. *Premium cost = Difference in material costs between standard and high-efficiency units. It does not include installation or other costs. Premium cost includes estimates for all units (CUs and furnaces).
Source: Practical Energy Solutions for DVRPC 2014

Best Practice #7: View Window Projects as Facility Investments, Not Energy Projects

In many buildings, failing windows are a real challenge. They can waste significant energy and cause comfort problems, yet replacing them is expensive. When evaluating window projects, it is important to understand that they are rarely, if ever, justified based on energy savings alone. Rather, municipalities must view window repair/replacement as necessary facility investments. As a result, municipalities may need to plan for this investment as part of their budgeting process several years in advance of purchasing windows. An advanced approach to incorporating windows in a municipality's capital budget gives the municipality time to prioritize the measure along with other purchasing needs, as well as time to evaluate and select the most suitable windows for the building.

However, there are options for minimizing costs—including exterior storms, interior storms, and insulated blinds/shades. In one municipality, deteriorating wood-frame windows covered 25 percent of the exterior, and were a significant source of air infiltration and employee discomfort. On behalf of the *Direct Technical Assistance* program, PES evaluated numerous options for the municipality and recommended a trial of operable, stay-in-place interior storms. Good-quality storms can provide energy savings comparable to replacement windows—saving approximately 18 percent of the space conditioning energy use in this building—while costing 80 percent less to install. As a result, they can be a viable stop-gap measure for municipalities that need time to plan for window replacements. Table 8 shows a comparison of estimated costs and savings for window replacement and interior storm windows. An interior storm provider should be able to determine if storms are a viable option for the remaining lifespan of your windows.

Figure 11: Municipal Building with 25 Percent Window Fenestration

Source: Practical Energy Solutions 2014

Table 8: Window Replacement/Upgrade Options

Measure Description	Annual Energy Savings		CO_2 Savings [lbs]	Energy Cost Savings [$/yr]	Est. Project Cost	Simple Payback [yrs]	Est. Product Life	Est. Savings Over Product Life
Interior Storm Windows	17,712	kWh	68,247	$ 8,430	$111,000	13.2	15years*	$16,860
	2,052	gal						
Replacement Windows	17,712	kWh	72,621	$ 9,083	$ 485,000	53.4	30 years	——
	2,247	gal						

Notes: *Manufacturer provides a 20-year warranty. The 15-year estimate is based on potentially heavy use of this municipality's interior storm windows, since they will be operable. Does not include cost to repair window frames. Contractor evaluation/quotation recommended. Savings based on current energy costs. Savings will change as energy prices change.
Source: Practical Energy Solutions 2014

Planning to Build a New Facility? Consider the Cost of Operation

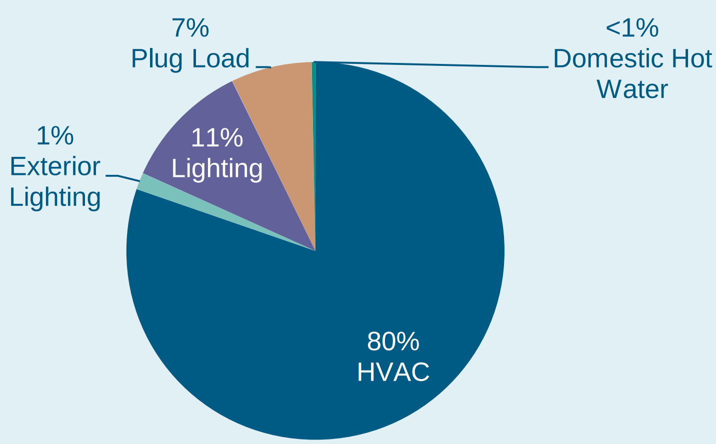
All too often, municipalities do not consider a building's cost of operation when making design decisions for new facilities. The end result is often a new building that is expensive to operate. This can eat away at the municipal budget year after year for the life of the facility.

The Circuit Rider Program experience suggests that designing efficiency into a building from the start can shave 30 percent or more off of the total energy bill. In the case of one new 13,800-square-foot police facility evaluated as part of the Circuit Rider Program, this approach would have saved approximately $400,000 in utility costs over 25 years (at today's utility prices).

To minimize your cost of operation when embarking on a new building project, focus on HVAC system design. As shown again below, HVAC systems typically account for the majority of energy use in municipal buildings. HVAC systems represent one of the most significant—yet overlooked—operational costs of any facility. Yet efficiency often takes a back seat due to perceptions that efficient systems are too costly to purchase, or because the HVAC engineer on the job is not trained in efficient design. Too often, money is invested instead in sophisticated HVAC control technologies, but these technologies won't produce operational savings if they're not paired with efficient equipment and good design, or if they're too complex to be programmed and managed properly by your own personnel.

When it comes to new facility design, the lesson learned is clear. Specify efficient HVAC equipment and overall system design, and controls that are simple enough to be managed by your staff. You will end up saving big in the long run.

Figure 12: Average Energy End Uses for Police/Admin Buildings



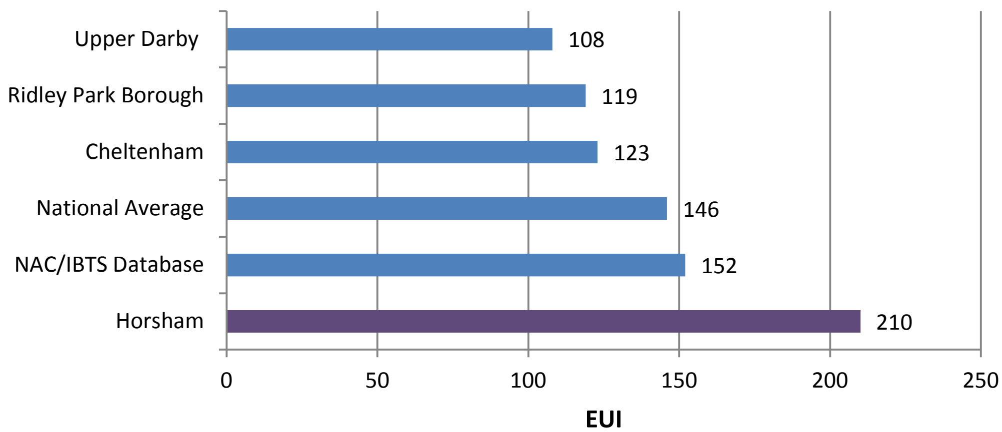
Source: DVRPC 2014

Best Practice #8: Don't Rule Out Energy Savings Just Because A Building is New

It's a common misconception that new buildings run efficiently just because they're new. In fact, new buildings can use more energy per square foot than older ones, due to sophisticated but uncontrolled HVAC systems and modern building envelopes that are not thermally efficient.

One of the municipal facilities evaluated through this program—a 13,800-square-foot police building constructed in 2009—is a case in point. This modern facility had an EUI that was 150 percent of the national average for police facilities (Figure 13, highlighted in purple) and a high energy cost of $3.60 per square foot despite competitive energy pricing—suggesting significant opportunities for energy savings. Despite its recent construction and sophisticated control systems, the facility's basic HVAC design is inherently inefficient. The building is served by an energy-intensive "reheat" system that represents a conventional, dated, and increasingly outmoded approach to summertime dehumidification. With this system, supply air is intentionally subcooled to remove moisture on hot, humid summer days. Then the air is reheated to setpoint temperature. This subcool-reheat method requires a significant amount of energy.

Figure 13: Police Facility Energy Use Intensity Scores



Notes: National Average: ENERGY STAR Portfolio Manager CBECS Database[6]. NAC/IBTS: National Association of Counties/Institute for Building Safety and Technology Database, from 101 police stations across the country.[7] **Source:** Practical Energy Solutions for DVRPC 2014

In this case, an energy assessment revealed numerous opportunities for reducing energy waste, including:

- Optimizing HVAC controls. PES identified multiple measures for gaining better control over the HVAC system.
- Installing higher-efficiency lights.
- Repositioning/upgrading misplaced occupancy sensors.

Together, these recommendations cut 13 percent off of the annual utility bill and are paying back in well under one year. For a complete overview of this project, see the Horsham Police Department Energy Assessment.[8]

6 www.energystar.gov/ia/business/tools_resources/new_bldg_design/2003_CBECSPerformanceTargetsTable.pdf.
7 www.naco.org/research/pubs/Documents/Infastructure%20and%20Sustainability/Energy—Efficient—County—Buildings.pdf.
8 Horsham Police Department Energy Assessment: http://www.dvrpc.org/Products/15024D/

Tips for Implementing Energy Management Opportunities

Energy management opportunities for municipal facilities are investments that pay for themselves over time due to improved operations or improved efficiency of replacement equipment. However, despite the long-term benefit of energy management strategies, municipalities still face the challenge of convincing their decision-making bodies of the value of large upfront investments. DVRPC's experience working directly with these nine communities highlighted a few key findings in the municipal decision-making process regarding investment in energy management.

- **Target low-cost measures first:** Low-cost measures that pay back quickly give municipalities the opportunity to demonstrate the benefit of energy management projects to their decision-making bodies, and they generate revenue streams from cost savings that can be put toward future investments in larger energy management projects.

- **Give your budget the heads up:** Several municipalities expressed that larger measures should be included in the budget several years before an investment is made, so that these measures can be properly planned for and prioritized. This strategy is an excellent option for measures that are not time sensitive (e.g., HVAC equipment that is nearing the end of its service life) because it gives municipalities several years to prepare and identify funding streams to pay for these larger measures.

- **Specific information is key:** Throughout the energy assessment process, PES communicated detailed information to the municipal staff involved in the project to ensure their buy-in and commitment. But when the time came to communicate these projects to council and finance departments—as well as to vendors and service providers—it was helpful to have simplified communication tools with specific details of the project, such as size, cost, and scope of work.

- **Where there's a will, there's a way:** Despite a lack of grant funds, incentives, or financing mechanisms, municipalities that saw the value to their community in the long-term savings from energy management projects were not hindered by fiscal constraints in their budget if they had properly planned for an energy management investment. For more costly investments, such as HVAC system upgrades, municipalities benefit from long-term strategic approaches that will require multilevel staff commitment and leadership.

Municipal Energy Management

Best Practices from DVRPC's *Direct Technical Assistance* Program

Publication Number: 15020

Date Published: April 2016

Geographic Area Covered:
Bucks, Chester, Delaware and Montgomery counties in southeastern Pennsylvania

Key Words:
Municipalities, energy management, Circuit Rider, buildings, lighting, HVAC, comfort, windows.

Abstract:
This guide highlights best practices and lessons learned from municipal energy management projects in southeastern Pennsylvania. In 2013 and 2014, DVRPC worked with nine municipalities in southeastern Pennsylvania to provide direct technical assistance with measuring, analyzing, and developing implementation strategies for energy management in municipal buildings. The goal of energy management is to identify opportunities for improving how energy is being used at a facility and to develop analyses that support decision making on how best to prioritize and implement these improvements. These improvements can remedy various problems—high energy and maintenance costs due to malfunctioning, poorly installed or aging equipment, poor occupant comfort due to a lack of weatherization, or poorly controlled equipment. This guide will illustrate several best practices for identifying and implementing energy management opportunities that save money and improve building comfort.

Staff Contact:
Liz Compitello
Research Analyst
☏ (215) 238-2897
ecompitello@dvrpc.org

Delaware Valley Regional Planning Commission
190 N. Independence Mall West, 8th Floor
Philadelphia, PA 19106-1520
Phone: (215) 592-1800
Fax: (215) 592-9125
Internet: www.dvrpc.org

DELAWARE VALLEY
dvrpc
REGIONAL
PLANNING COMMISSION

DVRPC, 8TH FLOOR
190 N. INDEPENDENCE MALL WEST
PHILADELPHIA, PA 19106-1520
215.592.1800
WWW.DVRPC.ORG