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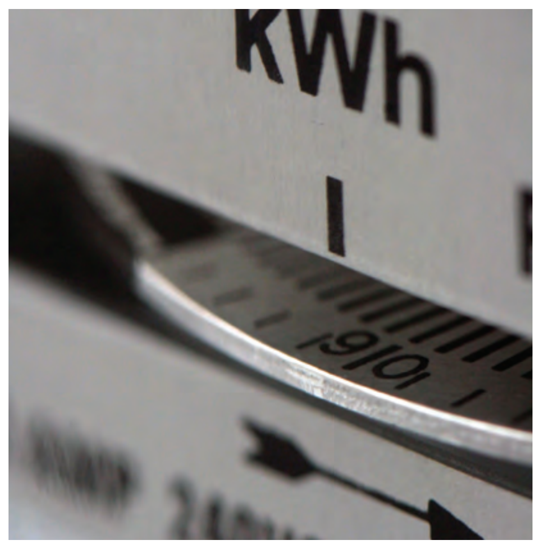

Finding Hidden Energy Waste with Data Loggers:
8 Cost-Saving Opportunities

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Finding Hidden Energy Waste with Data Loggers: 8 Cost-Saving Opportunities

Introduction

Statistics on utility bills or name plates on equipment, while useful, are not enough to identify what practices and equipment are contributing to high energy use.

Data loggers are small yet robust measurement and recording devices that can save companies significant energy costs. The first step to reducing costs is identifying energy waste. Statistics on utility bills or name plates on equipment, while useful, are not enough to identify what practices and equipment are contributing to high energy use.

It is often not necessary to invest in permanent metering. Simple temporary devices, such as HOBO® data loggers, can be used to obtain critical information at a fraction of the cost. More expensive metering can be added later if analysis justifies the value of a permanent monitoring system.

Information collected by data loggers can support proposed changes. Buying new energy-saving equipment requires capital, and changing operating schedules requires adjustments. Furthermore, the savings calculated through analysis of collected data typically justifies these projects.

In addition, with data loggers and a comprehensive understanding of how your utility company charges for energy, your facility can reduce peak demand charges. You can also evaluate the efficiency of air compressors in your facility, which are among the most common causes of industrial energy waste.

This best practices guide describes the data logging equipment you need to obtain information on energy consumption and environmental conditions in commercial buildings. It covers eight common forms of energy waste, and provides an overview of how to gather and analyze data and calculate savings for each opportunity.

Energy waste #1:

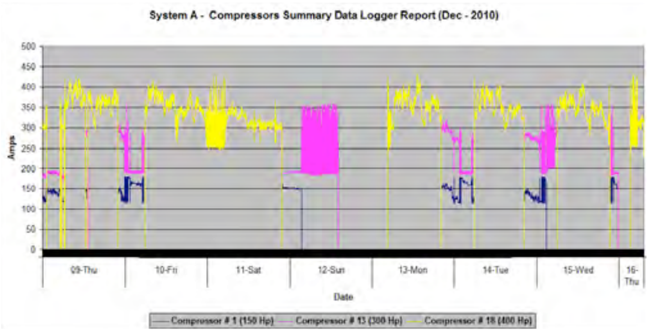
Improper Air Compressor Control

Compressed air is a very inefficient way to deliver energy throughout a facility. Less than 10% of the input energy ever does useful work, and 70% of the input energy is converted to heat at the compressor. However, compressed air is very common in factories because it serves many useful purposes.

One important aspect of the compressed air system is compressor control. When the system includes more than one air compressor, it is very important to understand how the machines share the load. Air demand in the plant almost never matches the rated output of all machines, so one or more machines run at part load (less than 100% output).

Partially-loaded compressors are not as efficient as fully-loaded machines.

The correct way to control the machines is to base-load all except one machine, which is designated as the "swing machine." The swing machine controls maintain system pressure by changing the output of the compressor as needed. All other machines are operated with constant output at their maximum efficiency point, or are idle if not needed to meet the load.



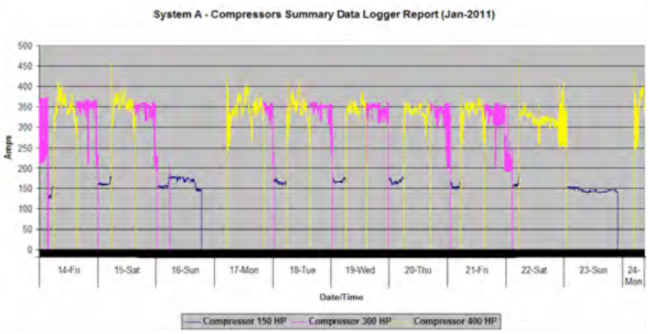
Air Compressors with Improper Sequence Controls

Data loggers are used to verify proper machine loading as follows:

1. Install a data logger and current transducer on one phase of each compressor and record load current for one week using a sample interval of 1 minute.

2. Calculate compressor input power at each 1-minute interval assuming nominal voltage and 86% power factor using the expression (Input Power [kW] = 1.732 x nominal line voltage x line current x 0.86 / 1000). A spreadsheet program is helpful.

3. Graph input power for all machines on one graph and verify that only one machine at a time operates at partial load. Contact a qualified compressor control vendor to correct the situation if more than one machine is partially loaded.



Same Air Compressors with Correct Sequence Controls

Other important observations – study your compressor input power profiles and consider:

1. What does it cost you to operate the air compressors for a year?
2. Does compressed air usage follow production activity?
3. How much energy (and money) is wasted on compressed air when the facility is idle?
4. How much of the compressor output do you think is leakage in the distribution piping?

Energy waste #2:

Inadequate (Compressed Air) Receiver Volume

An increase of just 10 psi will increase operating cost by 5%-8%.

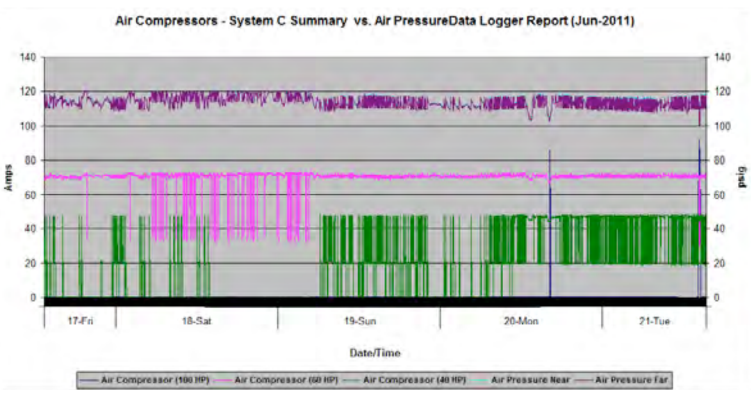
Increasing compressed air operating pressure dramatically increases cost. It takes more energy for the compressor to supply the higher pressure, and flow to unregulated loads/leaks is increased. An increase of just 10 psi will increase operating cost by 5%-8%.

Most industrial compressed air systems should be operated below 100 psig. However, pressure is often increased by operators in small increments over time and pressures of 125 - 130 psig are common. Many operators try raising pressure to resolve equipment issues that seem to be related to air pressure. Pressure is rarely reduced, even when the ultimate cause of the problem is found to be unrelated to pressure.

Before increasing pressure above 100 psig, it is essential to record and study air pressure profiles. It is likely that changes to distribution piping or the addition of receiver volume will resolve the problem without an increase in pressure and cost.

Adjusting the pressure should only be considered after pressure profiles are recorded and analyzed as follows:

1. Install a data logger and pressure transducer near the compressor and record pressure for one week using a sample interval of 15 seconds. In a similar fashion, install a second data logger and transducer at a location far from the compressors.



Compressed Air System with Inadequate Receiver Volume

2. Look for momentary drops in pressure that last less than one minute. If such events are recorded, make sure you have at least 3 gallons of receiver capacity for each cfm of air flow (see note below). Additional capacity should be added if necessary. Once these momentary pressure drops are eliminated, the overall operating pressure can be reduced.

3. Also, compare the data from the two loggers to determine the pressure drop from source to use of air. A drop of more than 10 psig indicates the distribution piping should be evaluated for proper size and condition.

Operating cost will be reduced by 5%-8% for each 10 psi in operating pressure reduction.

<u>Note</u>
Air flow [cfm] can be estimated using data loggers to measure compressor line current and the following formula:

Air Flow Rate [cfm] = 4 x 1.732 x nominal line voltage x line current x 0.86 / 746

Energy waste #3:

Excessive Peak Energy Use

Imagine driving an automobile from New York to Seattle without a working speedometer. Three weeks after arriving in Seattle, you receive several speeding tickets and a $1,000-fine for exceeding the limit in Iowa, South Dakota, and Wyoming. The value of real-time speed indication is obvious; you may have been able to avoid the violations, or at least would be aware of when and where they occurred. The same is true of commercial and industrial electric loads.

Most commercial and industrial electric rates include energy charges [¢/kWh] and peak power (demand) charges [$/kW]. Many users do not know when the peak usage occurred, or what electric loads contributed to the peak. Average electric load [kW], recorded every 15 minutes, is very useful in reducing peak power (demand) charges.

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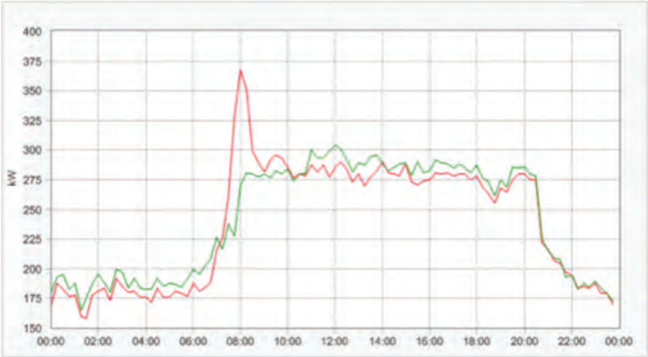
Data loggers are used to obtain load profiles as follows:

1. Install a data logger and current transducer on one phase of the electric mains for the facility and set the sampling interval to 1 minute. If the service exceeds 600 amps (maximum size CT available) and there are multiple conductors per phase, place the transducer around one of the conductors and assume current is identical in all conductors.

2. Calculate average power over a 15-minute interval assuming nominal voltage and 90% power factor using the expression (Power [kW] = 1.732 x nominal line voltage x line current x 0.90 / 1000). A spreadsheet program is helpful.

3. Study the profile and look for significant peaks in energy usage, such as in the example given below.



In this example, a small grocery store had a peak load of 359 kW at 8:00 every morning caused by simultaneous defrosting of all freezers (red line). The green line shows the resulting load profile one week later, after the timers where offset to avoid the peak load. Billing demand was reduced from 359 kW to 302 kW, resulting in annual savings of almost $10,000.

Energy waste #4:

Not Taking Advantage of “Free Cooling”

Many facilities operate chillers to provide water at 40°F to 50°F for manufacturing processes and space cooling. This requires refrigeration compressors, evaporators, condensers, cooling towers, pumps, and other equipment. The main energy consumer is the refrigeration compressor.

During certain times of the year, it is possible to provide the required chilled water without using the compressor when low outside temperature and/or humidity allow direct rejection of the heat to the environment. This is called “free cooling” and many facilities fail to take advantage of this opportunity to reduce cooling energy costs by 75%.

Free cooling requires capital equipment such as heat exchangers and controls. However, the savings often justify the investment.

Estimate the potential savings by first recording load current on one phase of each chiller compressor every minute for a week. Use the following expression to calculate hourly electric energy input:

Input Energy [kWh] = 1.732 x nominal line voltage x average load current [amperes] x 0.86 / 1000

Using a spreadsheet and the average unit cost of electricity [$/kWh], estimate average hourly operating cost [$/hour].

Next, refer to weather data and determine how many hours per year the outside temperature is below 46°F. This is the number of hours that free cooling may be practical. Estimate the annual value of free cooling by multiplying the hourly operating cost by this number of hours and then by 0.75.

Example Calculation

Consider four (4) 500-ton chillers operated year-round in central Nebraska. Average hourly input energy is determined from logged data records to be 764 kWh. Assuming unit electric costs of 6.3¢/kWh, operating cost is $48.13 per hour.

The outside temperature is below 46°F for 3,480 hours per year in central Nebraska. Since free cooling will reduce the operating cost by 75% (save $36.10/hr), the potential savings is 36.10 x 3480 = $126,000.

This is a budgetary estimate based on one week of operating data and some broad assumptions. Many factors influence the actual savings and more analysis is required. The purpose of this calculation is to get a feel for the potential benefit so free cooling can be considered for energy savings.

Energy waste #5:

Wasting Heat Energy

Air compressors must be cooled to remove the heat of compression. About 70% of the input energy is lost in this way. It may be economical to recover this heat and use it for winter space heat and/or process heat. The value of this energy is often underestimated.

Data loggers can be used as follows to determine the value of the waste heat so a recovery project can be considered:

1. Install a data logger and current transducer on one phase of the compressor and record load current for one week using a sample interval of 1 minute.

2. Calculate compressor input power at each 1-minute interval assuming nominal voltage and 86% power factor using the expression (Input Power [kW] = 1.732 x nominal line voltage x line current x 0.86 / 1000). A spreadsheet program is helpful.

3. Use a spreadsheet to estimate annual energy input [kWh] to the compressor.

4. Assuming 70% of this input energy is lost in the form of heat, calculate the value of this heat using your average gas cost [$/MMBtu] and the conversion factor 1 MMBtu = 293 kWh.

5. If the energy is to be used only for space heating (still rejected outside during the summer), reduce your value by the following ratio: number of hours per year when outside temperature is below 56°F / 8760. (Historical weather data should be used to determine hours below 56°F for this calculation.)

Example Calculation

Consider a 200-hp air compressor operated year-round in St. Louis, Missouri. Annual input energy is determined from logged data records to be 1,138 MWh. Since 70% of this energy is lost to heat of compression, that represents 797 MWh or 2,719 MMBtu. Assuming gas costs $8.50/MMBtu, the value of the waste heat is $23,110.

If the energy is to be used for space heating, we consider that the outside temperature is below 56°F for 3,528 hours per year in St. Louis and apply the factor 3,528/8,760 (or 40.3%). The energy is therefore worth $9,313.

It is often practical to recover heat using a simple air duct and summer/winter damper to direct the energy in or out of the building.

Other common sources of waste heat

- cooling towers
- hot exhaust
- boiler flue gas

Energy waste #6:

Gas-Fired Equipment Left Running

Gas flow meters are prohibitively expensive for most energy management work. However, data loggers can be used to monitor runtime on related electric equipment such as combustion fans.

Gas flow meters are prohibitively expensive for most energy management work. However, data loggers can be used to monitor runtime on related electric equipment such as combustion fans. Data loggers with CTV sensors can indicate when the equipment is operating, and a motor on/off logger can also record run status. Install one of these loggers for one week on your gas-powered equipment. Set the recording interval to every 30 minutes for 7 days.

Create a table for each piece of machinery monitored. Document the occupancy every 30 minutes in one column. Then add a column documenting whether the unit was running or not during each of the 30-minute intervals. For example, your analysis might identify a boiler left on over the weekend. For each 30-minute interval that shows no occupancy while the unit is left on, perform the following calculation to quantify how much money you can save if the unit was turned off during these times:

Amount of energy consumed per hour by unit x number of hours per week the unit is on while the area is unoccupied x weeks per year (52) x cost of energy per hour = money your facility could save by turning the unit off when the area is unoccupied.

Energy waste #7:

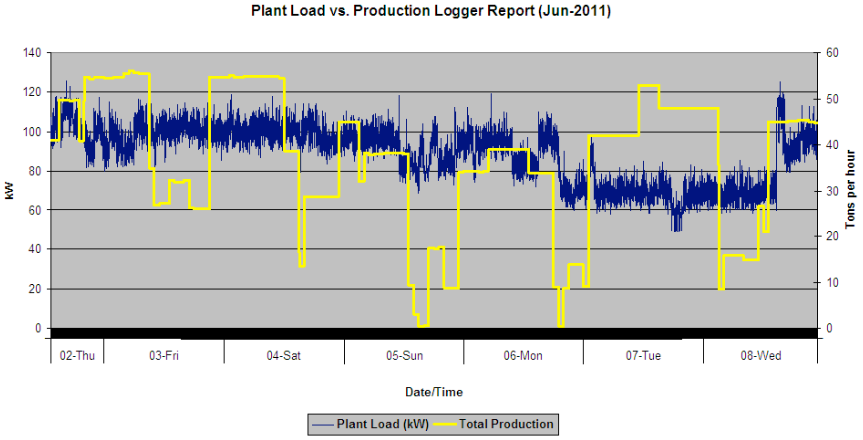
Electric Machinery Left Running When Not Required

It seems obvious and simple to save money by turning lights and equipment off when not in use. However, a surprising amount of energy and money is wasted every day in this way. Machinery that has been running for a long time might not restart properly; or machines may need to remain "ready." We're not going to tell you how to run your business; but data loggers can be used to determine what it costs to leave things running. Then you'll have solid data on which to base your business decisions.

Start by confirming when machines and lights are needed. Review production data and operating schedules, and discuss operations with workers. Then use data loggers and sensors to determine when the machines actually run and how much money is spent unnecessarily.

Create a table for each piece of equipment to analyze the data. Note whether it was on or off for each 15-minute period and if it was actually needed. For each unproductive interval, perform the calculation below to quantify how much money could be saved by turning it off. We assume it is a 3-phase electric power circuit and you measured current on one phase. We further assume a power factor of 86%.

- 15-minute Interval Cost [$] = 1.732 x nominal line voltage x average load current x 0.86 / 1000 / 4 x (cost of electricity in $/kWh)



Plant Load versus Production Activity (Brown Line) – Indicates large fixed load (significant waste and unnecessary loads)

Energy waste #8:

Not Sustaining Your Gains

You must control temporary alterations to sustain your savings over time.

Data loggers are often used to make significant reductions in energy usage and cost. Unfortunately, these gains are not always sustained over time; within six months to a year, energy usage returns to higher levels. The cause of this problem is temporary alterations. You must control temporary alterations to sustain your savings over time.

Example

A high-speed machine that places labels on soup cans is malfunctioning. In order to meet production targets, it is essential to get the machine working properly as soon as possible. The operator thinks increasing compressed air pressure will help, so pressure is increased (in the entire plant) by 5 psi. The problem persists, so other alternations are made to lighting, the HVAC system, etc. and the machine eventually begins to work properly

In a typical plant, that is the end of the story; problem "solved." In reality, the short-term problem may be solved, but those temporary alterations are now permanent with unintended consequences, like increased operating cost.

To be fair, the floor mechanics did their job, which is to get the machine running; that should not change. However,

- Did anyone really understand the problem and its causes?
- Were alternative solutions considered?
- Was the best long-term solution implemented?

To all the above questions, the answer is "probably not."

Recommendations

- Encourage your floor mechanics to continue supporting production and implementing short-term fixes.
- Require those same mechanics to report all temporary modifications so a formal problem-solving methodology that leads to the best long-term solution can be implemented.
- Don't allow a series of unreported, temporary modifications to permanently increase your energy cost.

Other informational resources available from Onset:

Choosing an Occupancy and Light On/Off Data Logger – 5 Important Considerations

This paper provides guidance on features to consider when choosing an occupancy and light on/off data logger, including calibration, LCD display, logger accuracy and range, speed of deployment, and time-saving software. Learn how to select the right logger for identifying ideal locations in your building where changes in lighting could result in cost savings up to 80%.

Utility Incentive Programs: How to Get More Money Quickly and Easily

"Utility Incentive Programs: How to Get More Money Quickly and Easily," is aimed at making the process of applying for and receiving energy efficiency incentives and rebates faster, easier, and more rewarding. Authored by Carbon Lighthouse, an energy firm that makes it profitable for commercial and industrial buildings to eliminate their carbon footprint, the paper discusses the two main types of incentive and rebate programs, how utility efficiency program managers think, and how to use data to get more incentive dollars for your projects.

Using Data Loggers to Improve Chilled Water Plant Efficiency

Chilled water plant efficiency refers to the total electrical energy it takes to produce and distribute a ton (12,000 BTU) of cooling. System design, water quality, maintenance routines, cooling tower design, and cooling coil load all affect chiller water plant efficiency and the expense of operating the system.

Data Logger Basics

In today's data-driven world of satellite uplinks, wireless networks, and the Internet, it is common to hear the terms "data logging" and "data loggers" and not really have a firm grasp of what they are.

Most people have a vague idea that data logging involves electronically collecting information about the status of something in the environment, such as temperature, relative humidity, or energy use. They're right, but that's just a small view of what data logging is.

Addressing Comfort Complaints With Data Loggers

This paper offers facility managers, HVAC contractors, and others with valuable tips on how low-cost data loggers can be used to validate temperature-related comfort complaints.

Monitoring Green Roof Performance with Weather Stations

Data logging weather stations are the ideal tools for documenting green roof performance. A weather station can measure weather parameters such as rainfall, stormwater runoff, temperature, relative humidity, wind speed, solar radiation, and a host of non-weather parameters such as soil moisture on a continuous basis (say every five minutes, hourly, or an interval appropriate to the situation).

Using Data Loggers Beyond Equipment Scheduling

While data loggers are a great tool for identifying equipment-scheduling opportunities in buildings, their usefulness far exceeds just that one function. This paper discusses how the use of inexpensive data loggers and some spreadsheet analysis can provide all the evidence needed to make powerful building-specific cases for saving money by replacing failed air-handler economizers. It also describes how information from data loggers can be used to accurately calculate the energy savings that can be realized from variable frequency drives (VFDs) on pumps and fans, supply air resets, and boiler lockouts

Analyzing Air Handling Unit Efficiency with Data Loggers

Operating a heating, ventilation and air conditioning (HVAC) system at optimum efficiency in a commercial setting is complicated, to say the least. There is a very real chance that any number of setpoints, levels, and feedbacks at boilers, chillers, pumps, fans, air delivery components and more can cause costly inefficiencies.

Finding Hidden Energy Waste with Data Loggers: 8 Cost-Saving Opportunities

The first step to reducing building energy costs is identifying energy waste. Statistics on utility bills or name plates on equipment, while useful, are not enough to identify what practices and equipment are contributing to high energy use. Portable data loggers can be used to obtain critical energy use information in a wide range of commercial building types – from manufacturing plants to office buildings.

Monitoring HVAC Performance with Data Loggers

Building operators and managers have the difficult job of providing comfortable working conditions and coaxing aging mechanical equipment to operate at peak performance while minimizing energy costs.

Access our full resources library at: www.onsetcomp.com/learning

About Onset

Onset is a leading supplier of data loggers. Our HOBO data logger products are used around the world in a broad range of monitoring applications, from verifying the performance of green buildings and renewable energy systems to agricultural and coastal research.

Based on Cape Cod, Massachusetts, Onset has sold more than two and a half million data loggers since the company's founding in 1981.

Contact Us

Our goal is to make your data logging project a success. Our product application specialists are available to discuss your needs and recommend the right solution for your project.

Sales (8am to 5pm ET, Monday through Friday)

- Email sales@onsetcomp.com
- Call 1-800-564-4377
- Fax 508-759-9100

Technical Support

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