Energy Saving in Manufacturing Facilities

Contents of e-book:

Introduction

Energy efficiency has always been a vital commodity in the manufacturing sector, but recent events from the past year have brought the discipline into much sharper focus.

More than ever, today's manufacturers cannot afford to waste a single joule if it can be avoided.

Of course, energy efficiency isn't simply about minimising operational costs or protecting the environment. Other key benefits include being able to extend the working life of their expensive equipment while boosting productivity and performance levels.

This eBook will help you get some answers to frequently asked questions on European standards you need to follow and how can you start reducing the energy waste and save money across your facility.

The Energy Challenge

The energy we use comes at a price. But that price doesn't only hold a monetary price, it also has environmental costs.
Greenhouse gases are a major contributor to climate change, and energy production accounts for two-thirds of global greenhouse-gas emissions.*
Experts expect electricity demand to increase by more than 40 % in 2030. * Although emissions are expected to remain flat,* this is way too high to fulfil the climate pledges made by over 150 countries at the COP21 conference in Paris 2015.

Because new technologies emerge slowly, experts claim that the agreed greenhouse-gas emissions for this century will already be reached soon after 2030.
The International Energy Agency (IEA) has formulated a "Bridge Strategy" to avoid this early peak in GHG emissions.
A major part of this strategy is improving energy efficiency in industry.

Energy Efficiency and ISO 50001

To improve energy efficiency in industry, the International Organization for Standardization has developed the voluntary ISO 50001 energy management standard. This is like the ISO 9001 quality management standard.
It is based on the proven PLAN–DO–CHECK–ACT cycle to improve industrial energy efficiency in a structural way.
ISO 50001 energy management in a nutshell:

Plan: Conduct energy reviews, establish baselines and energy performance indicators, set objectives and targets, and make action plans.
Do: Implement energy management plans.
Check: Monitor and measure processes against energy policy and objectives. Report results.
Act: Take actions to continually improve energy Performance.
Benefits: Save money on energy.

Avoid large carbon emission penalties.
Keep climate change under control.

* Source: IEA, 2015

Overview of Energy Demand

Although energy expenditure is a significant portion of overall operational cost, most companies do not have indications of whether energy consumption was standard or excessive in context with operations of the month.

Rising energy prices and sustainability requirements are pushing facility managers to improve their organization's energy efficiency. Electrical power usage is constantly changing. Which means loads on the electricity network are changing, resulting in energy waste. Discovering the source of this waste will allow organizations to develop strategies to reduce it. Although energy expenditure is a significant portion of overall operational cost, most companies do not have indications of whether energy consumption was standard or excessive in context with operations of the month.

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Benchmarking is critical

The first step in developing an energy management program is to benchmark the current state of electrical energy consumption across your facility. Through that initial survey, you can look for quick and easy solutions to start saving energy, like shutting down areas that are typically closed on the weekends.

Track areas that contribute to the energy usage outside of large assets, like supplementary air-conditioning systems and lighting or computers left on.

Once you've identified and implemented those quick wins, continue with more detailed studies throughout the facility. Run load and power quality studies on key critical assets throughout the area using the industry-leading Fluke 1777 Three-Phase Power Quality Analyzer, a certified IEC 61000-4-30 Class A edition 3 analyzer.

Engineered to be the faster, easier way to perform power quality studies with automatic measurements, Fluke 1777 comes with a straightforward user interface and setup, best-in-class specifications, and a simplified reporting platform.

What are the top critical systems to evaluate?

Electromechanical Systems

There are five common types of energy waste in an electromechanical system: electrical, mechanical/ friction, scheduling, controls, and sizing/efficiency.

Electric motors

Electricity is a major industrial energy source, and electric motors consume two-thirds of its worldwide*. Electric motors, are therefore, high on the list of energy-saving opportunities.

Old, inefficient motor systems may be around for many years. And while new systems are more efficient on paper, they may not be running under optimal conditions, leading to wasted energy.

Systematically and regularly checking the efficiency of your electric motors can give the baselines and energy performance indicators required by ISO 50001. You can also save energy and reduce expensive maintenance and repair costs. And you minimize process interruptions.

Three big factors influencing motor efficiency are:
• Motor Efficiency Class
• Motor Loading
• Motor Derating

Motor efficiency class

Most electric motors have an efficiency number on their nameplate. This number shows how well the motor should convert electrical into mechanical energy.

Motors come in different efficiency classes depending on their construction. The higher the class, the better the efficiency, and the less energy needed for the job

Different regions have different names for these efficiency classes. Two widely used classification systems are:
IEC: IE1/IE2/IE3/IE4
NEMA: Standard/High/Premium/Super Premium

Replacing a lower-class motor with a higher-efficiency class type requires an investment. But as initial capital costs are only about 1% of total costs over a 20-year motor lifespan (energy amounts to 90%)*, it pays to invest in energy-efficient motors.

Motor Loading

Motor loading is how well matched the specified motor capacity and the mechanical load are.

There are three basic load situations:

● Overload
The motor is too small for the task at hand. This will cause the motor to overheat. Which, in turn, will lead to a reduced lifespan, and may fail regularly. It will lose energy in the form of heat, resulting in low energy efficiency.

● Underload
The motor is too big for the task at hand. It will run at a fraction of its specified power and draw excessive and ineffective electrical current. As this current does not supply useful energy, efficiency is low. Utilities may demand penalties for this excessive and ineffective current.

● Nominal load
The motor capacity and the mechanical load are well-matched. The motor runs at its nominal specified power, using the energy to do the job as efficiently as possible. This is the preferred load situation.

* Source: Toshiba

Motor derating

Motor derating means the motor has to be used below its specified power due to poor quality of the electrical supply. Derating lowers the energy efficiency of the motor. Ignoring the derating can cause early failures and reduced lifetimes. There are four main reasons for derating:

Voltage unbalance

The three phases of the voltage supply do not have equal values. This causes mechanical strain and loss of efficiency in the motor.

Voltage harmonics

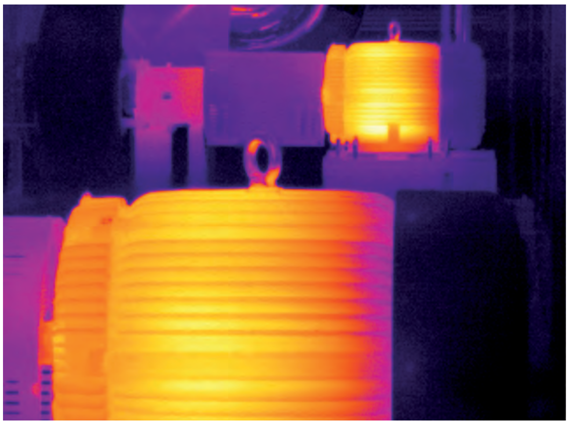
Other frequencies besides the fundamental 50/60 Hz are present in the voltage supply. This causes reverse torques and heat losses in the motor, which lowers motor efficiency.

Over / Under voltage

The voltage supply is either too high or too low compared to the specified motor voltage. Both situations lower the motor efficiency.

High temperature

High motor temperature has a negative effect on motor performance.



Impact of Power Quality on Electromechanical Systems

Harmonics distort the voltage and current, and as a result the ideal sine wave for voltage cannot be maintained. One of the most recognized effects of harmonics in electrical systems is the excess heat they create in the conductors carrying them due to the skin effect.

Easily view overall power quality health in accordance with international standards (e.g., EN 50160, IEEE 519, etc.) for faster troubleshooting with the Fluke 1777. This helps to prioritize and focus resources on mitigation solutions. Image 1 shows an overview of the PQ Health Mode, which is simple to read at a glance. The additional heat causes issues in cable runs, motor windings, and transformers. Overheating can cause significant damage or complete failure, either of which could lead to unplanned downtime and expensive repairs.

In the case of three-phase motors, unbalance degradesunit performance and shortens life span. Voltage unbalance at the motor stator terminals causes phase current unbalance far out of proportion to the voltage unbalance illustrated in Image 2.

Unbalanced currents, in turn, lead to torque pulsations, increased vibration and losses, mechanical stresses, and motor overheating. Using the Fluke 1777, these unbalanced issues can be quantified into a percentage value, as shown in Image 3.

Each of these effects consumes energy, now quantifiable in watts. The Fluke 1777 enables these values to be quantified, as depicted in Image 4. This gives a better understanding of useful and unusable power consumed by the loads.

Overheating and excess vibration, both detectable with thermal imaging and vibration, can manifest into energy-wasting mechanical situations. Possible causes of mechanical overheating and excess vibrations vary, from cooling and airflow, to bearing alignment and other causes of friction.

Image 1: Individual harmonics measured on Fluke 1777

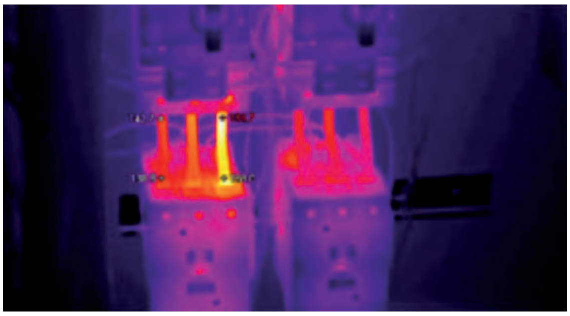


Image 2: Unbalance captured with a thermal camera

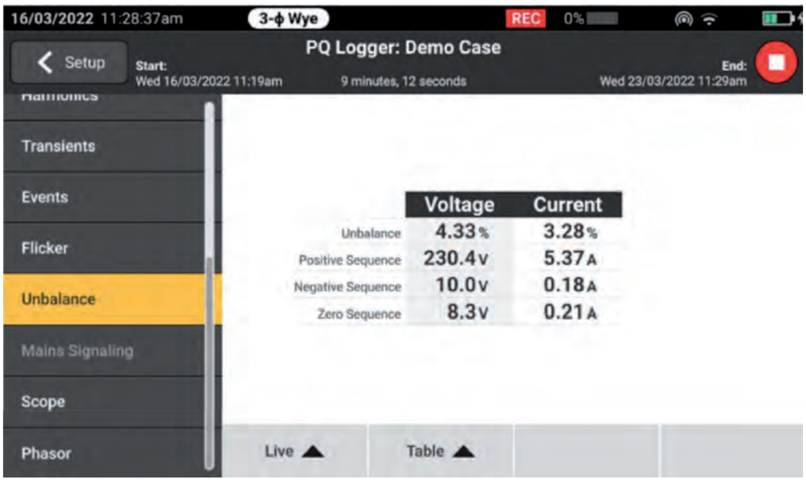


Image 3: Unbalance voltage and current table captured in the Fluke 1777

Image 4: Useful and unusable power captured by the Fluke 1777

The Fluke 805FC Vibration Tester (shown in Image 5) turns vibration data into machine condition answers. Understand the amount of vibration and bearing wear, location of the fault, severity level, and easy implementation in your maintenance routine.

Image 6 shows a technician completing a fault diagnosis on a motor coupled with a compressor setup with an external sensor. Other things that can signal inefficient operations and energy waste are thermally scan couplings, shafts, belts, bearings, fans, electrical components, termination/junction boxes, and windings.

Image 7 is an example of a misalignment in the motor installation.

Image 5: Fluke 805FC Vibration Tester

Image 6: Fluke 805FC with external sensor

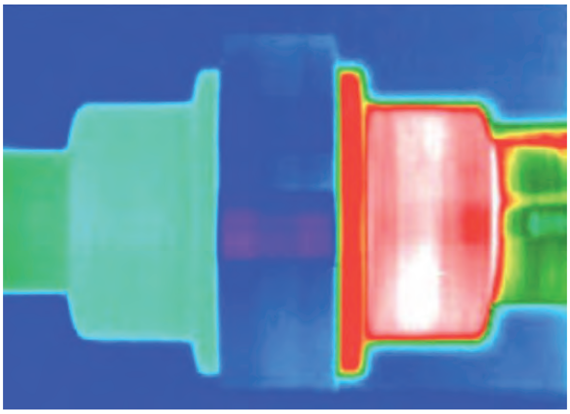


Image 7: Motor couple overheated due to coupling misalignment during installation process

Fluke Ti480 Pro used for motor inspections

One of the easiest energy-saving solutions is to log power consumption at large electromechanical loads over a full operational schedule. Determine when the machinery uses the most energy (often at startup) and check whether usage times can be adjusted to times when utility rates are the cheapest. You can also use a thermal camera to inspect machinery that does not turn on when it should.

Using that same power quality analyzer, compare the operational schedule to how often the machine uses energy. How much power is it using when not in active use? Without the use of controls, most machinery must be manually turned off to stop consuming energy, and manual actions don't always occur. Not all machinery can be turned off, but most can be left idle. Controls vary from simplistic to fully automated and from using sensors and timers to flexibly idle machinery to hard-coding operations into a PLC.

Comparing energy or power at different time intervals can be done with Calendar View, a feature of the Fluke Energy Analyze Plus software that is paired with the Fluke 1777.

In older facilities especially, operational requirements change, but the loads stay as is, meaning that sometimes a large, expensive, hard-start motor is left driving a less horsepower-intensive system. The natural inclination of any facility manager is to get the maximum lifetime out of a large piece of equipment. However, it's worthwhile to log how much power the motor uses and compare it to the actual load requirements as well as to a new, high-efficiency, right-sized unit.

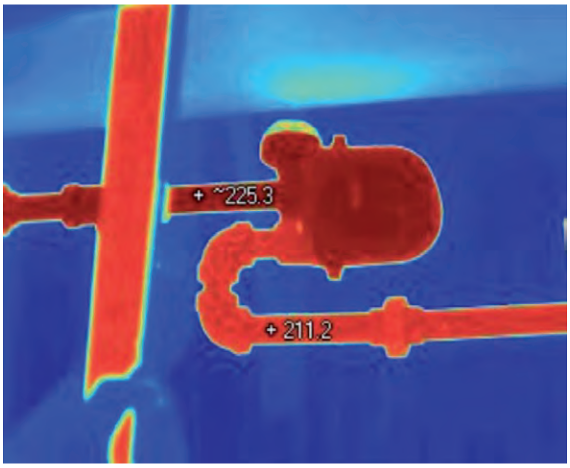
Calculate how much excess energy is being consumed and multiply by the rate schedule. Determine how long a new motor would take to pay for itself. It may make financial sense to replace equipment before it fails. If not, consider whether you could use controls modulate output.

Steam Systems

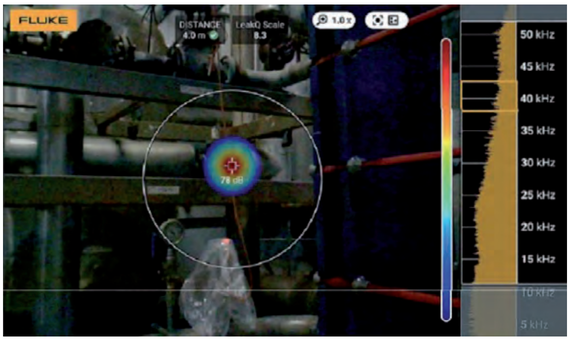
Process heating accounts for a sizeable portion of controllable operating costs, and you must regularly inspect the system to avoid several different energy-wasting scenarios. To begin, log energy consumption at the boiler to get a baseline for energy consumption. Next, inspect the distribution system, including steam traps, pressure gauges, insulation, pumps, and valves. Lastly, use a thermal camera to detect failed steam traps, leaks, blockages, value issues, and condensate failures: the goal is to return as much preheated condensate to the boiler as possible. The image shows an example of a failed steam trap where the outlet temperature is close to the inlet temperature.

Apart from thermography, you can also use an ultrasonic leak detector to check for steam leaks. Be sure to check for loose or missing insulation and proper operation of all steam traps, clean inside boilers, and check steam transmission lines for blockages. These combined efforts identify energy wastes and help the team plan energy-saving solutions - many of which you can often implement via maintenance rather than a capital expense.

The image shows a steam leak captured using the Fluke ii910 Acoustic Imager. You can greatly cut the time it takes to detect leaks with this technology. The simplicity of the Fluke ii910 enables a user with little-to-no experience to start detecting leaks right away. Steam, compressed air, gas, and vacuum leaks can be easily detected from up to 70 meters.



Failed steam trap captured with a thermal camera



Steam leak captured with the Fluke ii910 in a food and beverage manufacturing plant

Compressed Air Systems

A 100-horsepower air compressor can consume around $50,000 in electricity annually, and as much as 30 % of that electricity goes to pressuring air that is never used* due to distribution leaks and wasteful usage practices. Many facilities have never assessed the efficiency of their compressed air operation. In fact, when more air pressure is needed, many facilities will purchase and operate an additional compressor without realizing they could get more pressure out of their existing system. The image below shows a typical compressor cycling trend when leaks are not fixed. In reality, compressed air is a fairly expensive commodity to produce. Image 10 shows excessive compressor cycling due to compressed air leaks, logged on a power quality analyzer.

To identify and quantify the level of waste, start by logging power over a full business cycle at all air compressors. This will establish how much energy it takes to produce current air pressure levels. Use an ultrasonic leak detector to scan as much of the air-line footprint as possible to determine the location and scope of air leaks.

The image shows compressed air leak detection in an extremely noisy glove manufacturing. The Fluke ii910 can filter through these disturbances and focus on leaks that matter.

The image shows a leak in the main compressed air pipe flow for an electronics manufacturing plant. When the leak is not easily accessible, the Fluke ii910 comes in handy to pinpoint the leak location.

Effective steps to improve energy efficiency include:

- fixing identified leaks,
- setting compressors to generate only the necessary amount of pressure,
- installing air shutoff solenoids at point of use; and
- using receive tanks for high-volume applications rather than increasing overall system pressure.

* *Improving Compressed Air System Performance: a Sourcebook for Industry: Section 12, "Compressed Air System Economics and Selling Projects to Management," p. 69.*

Conclusion

Once you establish a path to identify energy wastage and reduce energy consumption, would you funnel those savings into increasing plant yield (same kWh consumption producing greater volumes) or to other business strategies such as increasing profit margins or price realization?

Recovering energy wastage is beneficial to manufacturing facilities. By logging and analyzing each major system and mapping those costs against utility bills to quantify where and when consumption occurs, companies can often realize savings by simple operational and schedule changes.

Identifying inefficient equipment with smart tools means companies can justify and prioritize replacement. And by reducing overall energy consumption, companies reduce operating costs, improving their competitiveness in the marketplace.

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