Industrial Assessments: Tips from the Field

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Are You Planning to Conduct an Energy Audit at an Industrial Facility?

Whether you are just stepping into the field of industrial energy assessments or you have been conducting assessments for some time, you probably already realize what an arduous undertaking this task can be. Tackling energy efficiency in the industrial sector is the most complex of all sectors because no two industrial facilities are alike. Every process is unique, and each manufacturing site typically has specialty equipment that is unique to their particular product. Short of working as a plant engineer or maintenance manager for several years at a particular facility, it is unlikely you will become an expert in all the plant's processes prior to performing the energy assessment. If you are not an employee of the facility, you will not have much time for data gathering, general observations, or field tests during the assessment. However, the following general tips can help make your audit go more smoothly and yield more thorough results.

Let's assume…

- You are reasonably well-versed in industrial energy systems;
- You are familiar with best practices;
- You have read most of the energy tip sheets available from the U.S. Department of Energy's Advanced Manufacturing Office (formerly the Industrial Technologies Program);
- You are familiar with and may have even downloaded a software tool such as SSAT (Steam System Assessment Tool) or PSAT (Pumping System Assessment Tool) and received training to effectively use said tool;
- You have your steel-toed boots, hard hat, clipboard and a few instruments with which to gather data; and
- You are ready for the plant tour and the mission at hand.

What else do you need?

We consulted a few seasoned industrial energy systems experts that have over 80 years of combined field experience to get their advice for conducting field assessments. The following are some tricks of the trade you won't find in a training manual. Tuck these ideas in your back pocket and see how they will help you make the most of your limited time in the plant and with plant personnel.

Pre-Assessment Homework

Make sure you've done your homework before arriving on site:

- **Discuss the assessment process and goals with plant management** to ensure that the plant has the time, budget, commitment and appropriate staff to dedicate to the assessment and implementation of the measures that are identified. Find out if the facility is capital constrained, manpower constrained, or unwilling to risk production downtime to make changes.

- **Make sure an assessment is done only if the plant welcomes it and demonstrates a commitment to implementing improvements**. Plant staff should not adopt the philosophy that an energy assessment is "free"; that will undermine the value of the service you are providing. To get management's commitment to implement improvements, you are going to need to speak the same language as management.
- **Take time to understand how decisions are made and the key factors used for project selection at this company**. Deliver project recommendations in economic terms that management understands, such as return on investment, payback and internal rate of return.

Rate Schedule Analysis

An engineer identified annual savings of $20,000 that could be achieved simply by switching to a rate schedule that more closely aligned with the facility's hours of operation, rate of consumption, and maximum consumption.

U.S. Department of Energy

Visit the U.S. Department of Energy's Office of Advanced Manufacturing website: *http://www.eere.energy.gov/industry/*, which offers case studies, software tools, and industry-specific information.

- **Know what resources are available to you during every step of the assessment**, including knowledgeable plant staff and outside resources.
- **Obtain a copy of the plant's utility bills and compare the rate structure that is used with other possible rate structures the utility offers**. Savings from adopting a new rate schedule may actually dwarf the savings from implementing energy efficiency measures, and may free up extra funds with which to implement the measures you recommend.
- **Contact the utility and inquire about available incentives**. Some utilities offer a custom incentive program that can be applied to industrial energy efficiency projects. Find out from the utility what data is required, what forms need to be submitted, and the process for measuring and verifying results.

These two engineers are working as a team to collect and record combustion data on natural gas burners.

Kick-off Meeting

When you arrive on site, have a kick-off meeting with plant management, engineers, and operations/maintenance staff who will be assisting you.

- **Build a rapport with the folks you are going to be working with**. A box of donuts has been known to make many a plant operator smile during a morning meeting.
- **Clearly define roles and expectations so plant staff knows what assistance you will require throughout the assessment.** Understand the boundaries and know when to ask for help before deploying instrumentation and collecting data.
- **Take photos to help you remember the location, size, orientation and**

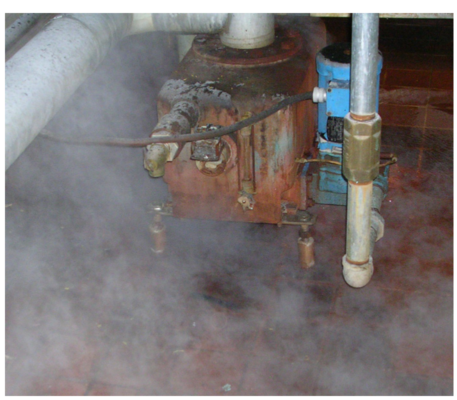
condition of equipment and related piping. Ask permission beforehand as there may be certain areas where photography is not allowed if the process or equipment is proprietary. You may also want to take a digital voice recorder to help log your observations.

- **Ask if there are any abnormalities in the plant that day.** For instance, upon arriving at a facility to perform a steam system assessment, you may discover that the deaerator is temporarily out of service. That fact would need to be taken into account in the data evaluation of the boiler feedwater temperature.

Plant Tour

Your tour of the plant should ideally be led by a knowledgeable engineer or operations personnel.

- **Ask the operator if there are recurring problems in the system you are evaluating**, such as water hammer in piping or noise from excessive vibration, even if it is not present at the time of the assessment. Asking these questions may provide insights about system inefficiencies.
- **Keep in mind that equipment is frequently oversized to accommodate surges, peak production times, or meet demand from anticipated expansions.** An oversized system can frequently be consolidated by taking one or more pieces of equipment out of service, which reduces the overall plant energy demand.
- **Watch for equipment that is out of place or used improperly.** Spotting these problems generally takes a trained eye and years of experience, but it is an important skill to start cultivating now.
- **Watch for steam and condensate leaks.** If you are conducting a steam system assessment, most of your time will be spent in the boiler room. However, take time to walk around the plant and observe the steam end uses. If you see excessive condensate leaks, there is likely an opportunity for heat recovery by improving the condensate return system. Ask facility personnel about their steam trap maintenance program. If it has been a while since the traps were inspected, chances are that many of them have failed and are wasting energy.



Document the number of steam and condensate leaks while observing steam end uses.

Consider a New Approach

An engineer found that a food processing facility utilized two different-sized rotary screw air compressors – a 75hp compressor during off-season and a 100hp compressor during peak processing season. During the assessment, the engineer asked the operator if the 75hp air compressor was sufficient to meet peak-season needs and offered to run an extended data logging test to track long-term operation of both compressors. The operator allowed the respectful challenge of the conventional approach and was pleased to learn that the 75 hp compressor was sufficient to meet the plant's needs most of the time.

Consolidate Equipment

When evaluating a large pump that was operated at dead head conditions with frequent surges and vibrations, the assessment team noticed that a neighboring pump, which was not part of the scope of the assessment, was also surging and vibrating and appeared to be oversized. The pumps were pumping from the same source, so the assessment team proposed consolidating the system, making some piping and flow control changes, and taking one pump out of service.

- **Look for opportunities for lighting retrofits, even if the focus of the assessment is not lighting.** Many industrial plants and manufacturing

Note Out-of-Place Equipment

During a plant tour, an engineer noticed an air compressor that seemed out of place. When he inquired about its purpose, he was told that compressed air from the modified air compressor was used to supply hot air to dry printing ink applied to plastic film. This was an inappropriate use of compressed air, which is a very expensive utility. All similar systems at the plant utilized direct gas-fired air handling units that supplied the drying air at approximately one-sixth the utility cost of operating the air compressor. Other inappropriate uses of compressed air are: tank mixing, blowing surface moisture from products, cleaning work areas, and cooling.

facilities still use 400 watt metal halide lighting. Upgrading to fluorescent lighting yields quick and significant energy savings, especially if utility rebates are available. Lighting retrofits can be packaged with other energy-saving measures to improve the economic payback of the combined measures. However, keep in mind that installation of new lighting fixtures may be pricey and inconvenient if light fixtures are in limited access areas. It also may be challenging to identify time periods to do the installations so you do not impact production areas that operate continuously.

Begin the Energy Assessment and Collect Data

Corroborate Data

- **Consider a two-person team approach if you are doing an equipment inventory.** One person can look for nameplate information and make general observations while the second person records the data.

- **Bring your own portable instruments**, such as a pressure gauge, temperature measurement and flow measurement devices that you know are accurate. Do not assume that the existing plant instruments have been recently calibrated.

- **Ask permission to verify plant readings**. Look for ways to corroborate the data you are collecting using available plant resources. These may include:
  - Tank level changes translated to volume change to obtain flowrate out of tank.
  - Gas meter billing readouts, especially if the gas flows only to the system under study (may need temperature/pressure/heat value corrections to convert to standard volume or energy units).

An engineer verifies water flow rate using the bucket and stop watch method.

  - Water and other meter readouts for the process(es) being investigated.
  - Pump performance curves to estimate pump flow from line pressure and motor electrical demand measurements.
  - Facility-installed instrumentation for direct measurements, and possibly electronically archived data such as in a SCADA (Supervisory Control and Data Acquisition) system.
  - Handwritten log sheets for historical measurements.

Check for Valve Leaks

If working in a process that is presumably a closed system, check the process inlet and outlet and verify (don't assume) that control valves are operating as intended. For instance, valves and actuators can become faulty over time and begin leaking, thereby allowing "tramp air" into a system.

Identify Leaking Valves

To check for valve leaks, an engineer performed this simple test: he placed a piece of notebook paper in the ambient air inlet port to a thermal oxidizer. The purge air inlet valve was supposed to allow ambient air into the oxidizer only during equipment start-up. He observed the paper stick in place from the action of air moving through the partially open valve. This indicated a significant air leak on the inlet to the thermal oxidizer. Unknown to plant staff, the oxidizer had been operating in this inflated-load condition for quite some time. By ensuring the purge valve was completely sealed, the oxidizer reduced its thermal load and fuel requirements by 3% per year, saving the company $9,000 annually.

An Energy Engineer monitors the temperature and oxygen content of flue gas.

Verify Performance of Previous Efficiency Improvement Projects

If a system already has energy-saving components installed, verify that these components are operating properly and achieving the expected results.

Verify Performance of Control Systems Between Shifts

When you assess a system that has to be cleaned, such as a dairy's milk-chilling process, or a batch system with periods of downtime between operating shifts, remember to monitor the process during the off-periods to make sure no energy is wasted during these times.

Save Energy by Improving Product Reject Rates

Watch for scrapped or rejected product rates and determine the embodied energy wasted. One engineer found that a plastics manufacturer's multi-extrusion line facility had a rejection rate of approximately 35 percent of its product (including unavoidable "trim" scrap). If "first time quality" was improved to 100 percent and only unavoidable trim scrap remained, the facility could reduce its overall energy use by an estimated 30 percent.

Look for Opportunities for Waste Heat Recovery

When exploring options for waste heat recovery in a plant, the rule of thumb is that the heat sink should have good "coincidence" with the heat source. Coincidence means that the "need" for the heat exists when the surplus heat

Stack exhaust is a good example of recoverable waste heat in a plant.

Make Routine Adjustments

During an industrial steam system assessment, an engineer noted that two identical boilers had flue gas sensors to detect the oxygen content of combustion exhaust. Flue gas oxygen content is monitored to verify that an optimum amount of air is being supplied to the boiler's burners. The sensors indicated that excessive oxygen was present in the flue gas streams from both boilers. The engineer pointed this out to operators who were not aware of the cost and energy penalties associated with improper combustion ratios. They made routine adjustments from that point on so that the oxygen readings would stay at more optimal levels. This quick, minor action was quantified as saving $90,000/year due to reduced natural gas use.

Implement a Proper Control System

An engineer noticed the lack of a proper control system on a dairy's milk chilling process. The heat exchanger incorporated two cooling circuits, one using well water and a second using chilled glycol. The heat exchanger functioned efficiently during normal operation; however, during the hot water wash cycle, the well water and chilled glycol pumps continued to operate while hot water was pumped through the milk pipes. The system was cooling and heating simultaneously, wasting energy in pumping (well water and chilled glycol), and refrigeration (to remove the heat exchanged from the hot water). In addition, the hot water temperature was reduced, risking the effectiveness of the sanitation process. The fix was simple: the operator turned off the pumps and closed a couple of valves so the system did not continue to cool and heat at the same time.

Capture and Re-use Waste Heat

An estimated 100 gallons per minute of clear water was being discharged to a paper plant's wastewater system. The source of the water was found to be once-through cooling water used to keep a solid fuel boiler's grates from overheating. Capturing this warm water and using it to supply a nearby boiler make-up water reverse osmosis treatment system saved energy and water costs of $30,000 per year.

is available. Boiler flue gas is the classic example of waste heat in a facility. To find a use for this waste heat, first look for a heat sink within the boiler system, such as preheating boiler feedwater. In this case, hot feedwater is needed at the same time that surplus heat from the flue gas is available. Other heat sinks, such as preheating product elsewhere in the facility, may involve batch operations, where the need for the heat does not exist 100 percent of the time that the boiler is in operation.

Post Assessment Presentation

After the data collection and analysis are complete and you have found what you believe to be the best opportunities for energy savings, present these ideas to plant management. There is an art to doing this that will yield more effective results. You will most likely present energy efficiency measures along with corresponding annual savings and maybe even an expected payback period.

Be sure to mention the "cost of doing nothing," as Christopher Russell states in his book, *The Industrial Energy Harvest* (2008). The cost of doing nothing goes up as the price per unit of energy goes up and as interest rates decrease, making the cost of energy improvements more affordable and increasing the annualized net savings of a project.

Plant managers and operators are frequently lulled into complacency, allowing the same maintenance problems and energy waste to persist year after year. There is a chance that your energy savings assessment report will remain on a shelf unless the management is compelled to act.

This cooling tower water discharge could be evaluated for possible heat recovery.

Highlight Non-Energy Benefits. Mention the non-energy benefits of implementing the measures you found. This will include items such as ease of operation, equipment reliability, decreased downtime, employee comfort and safety, and improved environmental outputs.

Add a Sense of Urgency to Your Presentation to Management. Find out about timing deadlines for possible incentives, which should help encourage management to take action.

Educate Plant Management About the Triple Bottom Line. This is the sustainable business model that optimizes financial, environmental, and social performance all at once. Industry has a social responsibility to reduce waste and conserve energy in order to not overtax the existing power generation and distribution infrastructure. Continuing to live with energy waste will cause accelerated investments in power generation capacity and higher energy prices for all users.

Learning From Experience

There are many guidebooks and resources that outline successful assessment procedures and principles. One useful resource is the new U.S. Department of Energy document *Guiding Principles for Successfully Implementing Industrial Energy Assessment Recommendations* (2011) that you can download at *http://www.eere.energy.gov/industry/pdfs/implementation_guidebook.pdf*. This guide is intended for plant management and may help you with effective delivery of your assessment recommendations.

We hope that the ideas presented in this article, by industrial energy system experts, will help you to refine your energy assessment practices. As you conduct assessments and network with your colleagues, keep your ears open for additional tricks of the trade. The complex and unique nature of industrial energy systems ensures that you can have endless opportunities to expand your knowledge and skills.

WSU Extension Energy Program Mission Statement

To advance environmental and economic well being by providing unmatched energy services, products, education, and information based on world-class research.

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