How to Find Energy Savings In Process Plants
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Summary

Process plants can make significant reductions in energy usage, with appropriate focus. Using the techniques presented in this paper, it is typical to see energy savings from 0.5% to 2% of total energy cost, with some plants seeing as much as 20% reduction. These techniques can be applied with little capital investment.

Introduction

This paper is focused on making your existing process run more efficiently. We will avoid expensive process equipment changes, and focus on ensuring the optimum performance of your existing equipment, operations, and controls. As shown in Figure 1, managing performance of these 3 areas drives long-term results in quality, throughput, reliability, material and energy costs. In this chart, improvement opportunities are shown in yellow or red. Resolving the short-term opportunities causes improvements to Energy Cost, Unit Cost, and Profitability.

Figure 1. Managing Process Performance

In this paper, we will identify how to find energy savings opportunities by looking at the right metrics of performance for operations, equipment, and controls.

Focus on the Right Process

If you want to save energy, the first thing to do is identify the parts of the plant that consume the most energy. Be sure to consider the following forms of energy:
• Fuels (Gas, Oil, Coal, Wood, etc.)
• Steam
• Electricity
• Chilling/Refrigeration Systems
• Compressed Air (For the work done, the most expensive form of energy)

If you find yourself thinking about boilers, reactors, drying, and separations operations, you are on the right track. These tend to be the most energy-intensive parts of a process plant. Every plant is different, and your focus depends on the specific process design of your plant.

**Measure the Right Things**

If you’re like most plants, you probably know how much energy you use, and you probably even know your energy spending per unit of production. It is common to see charts of MMBTU/ton, fuel efficiency percentages, and $/ton. But knowing how much you have spent doesn’t tell you how to spend less!

To understand **how to spend less on energy**, you need to measure the right short-term performance measures. For example, reducing oscillations (a short term measure) has a direct effect on energy savings. Reducing the “Opportunity Gap” pushes the process closer to its optimum, typically saving raw material or energy expenses.

For the best results, the short-term measures should be meaningful and actionable. This way, you will find opportunities quickly, identify problems as soon as they occur, and take immediate actions to correct or improve the process. In the sections below, we will look at some of the right measures for improving energy performance for operations, equipment, and control systems.

**Operations Performance**

Operators manage hundreds or thousands of items in an average shift. Energy concerns compete for the operator’s attention, along with production, quality, training, and other cost-savings. To make matters worse, it is unlikely that even the most obvious energy-saving measures are being monitored. Some of the most important measures are described below.
Opportunity Gap Delivers Immediate Results

The Opportunity Gap is one of the best ways to find process improvements. The Opportunity Gap can be defined as “The opportunity to move the setpoint closer to the specification limit.” The larger the Opportunity Gap, the more money you can save. Figure 2 shows how you can shift setpoints to benefit from a large Opportunity Gap.

Opportunity Gap is actively used in Oil & Gas industries, for example, it is used to optimize composition and reduce operating expenses. In Chemicals, Opportunity Gap is used to meet product specs at the lowest possible cost. In the Pulp & Paper industry Opportunity Gap minimizes product basis weight, reducing product give-away, as well as moisture content, minimizing energy use.

In Figure 3, we see how one chemical company use Opportunity Gap to make a series of setpoint changes, resulting in energy savings of over $1,000,000 per year.
Opportunity Gap can be easily calculated from existing control system data. In a typical scenario, you will work to reduce process variability, and then shift the setpoint closer to the spec limit. In drying operations, manage the Opportunity Gap for moisture content. For distillation columns, manage Opportunity Gap for composition.

With such a clear measure of performance, operators will quickly learn to make process adjustments, and the process will show improvements immediately.

**Oscillation Detection Saves Money**

Is your car more fuel efficient when cruising down the highway at a steady speed? Or is it better to constantly cycle the gas pedal? The answer is obvious: maintain a steady rate of speed, and you will get better fuel efficiency - **Even though the average rate of speed is the same!**

The very same thing is true in your plant, especially when we are discussing energy consumption. When you are looking at temperature, air/fuel ratio, moisture content, and steam pressure, **cycles are major problems for energy efficiency.**

Oscillation Detection technology will automatically identify, measure, and analyze the cycles in your plant. A Performance Supervision System identifies common causes of cycles, and traces them back to their root cause.
Whether the cause is equipment, controls, or process operations, eliminating the cycle will improve energy efficiency and help to stabilize the operation. According to Rowdy Boudreaux, Furnace Operator at Columbian Chemicals North Bend plant in Louisiana, “It makes my job a lot easier.”

There is plenty of room for improvement: In studies of plant operations, we have found that it is typical for 40% of measured variables to be cycling!

**More Operating Efficiencies**

There are, of course, many more ways to affect energy savings in operations. A few more measures that can help are:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Effect on Efficiency</th>
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<tbody>
<tr>
<td>Time in Normal Mode</td>
<td>Controllers left in manual are not able to respond to process upsets. Also, they are typically hiding an equipment or control problem.</td>
</tr>
<tr>
<td>Valve At Limit</td>
<td>Indicates that a part of the process may be at the limits of its capacity.</td>
</tr>
<tr>
<td>Alarm Rate</td>
<td>When distracted by too many alarms, the operator is not focused on plant performance.</td>
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</tbody>
</table>

**Control System Performance**

Ultimately, the job of the control system is to reduce plant variability. As we have seen above, oscillation and other variability leads to inefficiency.

Poor controller tuning is another source of variability in plants. If a controller is tuned too sluggishly, then it does a poor job of responding to upsets. If it is tuned too aggressively, then controller will actually increase variability in the plant: this is exactly the opposite of what we want.

**Robustness and the ExperTune Index**

Robustness refers to the controller’s ability to handle a range of upset conditions. If the controller is not robust, it will tend to oscillate, and could even become unstable. This situation, could lead to a process shutdown. So for controls to respond appropriately, you should pay attention to the controller robustness. Figure 4 shows a robustness plot that can be used to select optimal controller tuning.
The ExperTune index is a measure of controller performance, and includes robustness as a component. When you measure and manage loop performance, you eliminate another source of process variability. Figure 5 shows an automated report of these factors on a prioritized basis. Any loop with a large ExperTune index is an opportunity to improve performance and reduce energy costs.
Many large, sophisticated plants have attempted to improve performance with Advanced Process Controls, such as Model Predictive Controllers (MPC). Unfortunately, many of these efforts fall short, because system performance degrades over time.

A Performance Supervision System will also keep a close watch on your advanced control program. When the system is not being used properly, or when its performance inevitably starts to decay, the Performance Supervision System can alert you to the issues. There are many specific measures that will help you to diagnose the issues with MPC. For example, you can assess controller service factor, constraints, prediction accuracy, and entropy. Each of these measures will help you to take corrective action, and keep the advanced controls running at their best.

More Control Assessments

There are, of course, many more ways to assess and improve controller performance. You could look at traditional measures, such as Integral Absolute Error (IAE), the Harris Index, Relative Response Time, and many others. All of these measures are available in a full-featured performance Supervision System.
**Equipment Performance**

We must not forget that the control room is connected to some actual equipment. And equipment wears, plugs, leaks, and breaks. When these things happen, the process again loses efficiency. There is no substitute for a good predictive and preventive maintenance program supported by a performance supervision package. The maintenance program can be only as good as the data available to it. This section discusses some key measures of performance that will help to keep plant equipment operating at its best.

**It’s the Valves, Man!**

Control valves are everywhere in process plants. They control just about everything. And they are in terrible shape. They leak, they stick, they slip, and sometimes they don’t do anything. In over 20 years of studying control valve performance, we have discovered that fully 35% of control valves installed in plants have serious problems. It doesn’t matter how good your operators and control systems are if the valves don’t work!

So if we want to improve the process, we need to focus on the valves. Some of the key measures for valves are:

- Valve Travel
- Hysteresis, also known as “lost motion”
- Stiction (and oscillation due to stiction)
- Valve Size (is it over-sized or under-sized?)

“Poor Controller Tuning Affects Valves”, published in *Control Magazine* (March 2002, pp47-51) showed that proper tuning and repair of valves can save over $500 per year in electricity costs alone.

**More Equipment Issues**

Pay close attention to each piece of equipment that consumes energy. For example:

- Dryers
- Heat Exchangers
- Columns
- Boiler Drums

When you measure and track a dynamic model of each piece of equipment, you will be able to detect fouling, plugging, blown seals, and other factors with a direct impact on energy consumption. In the past, this has required substantial engineering calculations. Today, this can be accomplished automatically with Active Model Capture Technology. Active Model Capture Technology works by monitoring the process continuously, 24 hours a day. It looks at process changes created by setpoint changes, mode changes, and
disturbances to develop a dynamic model of process behavior. This model includes a wide variety of fundamental and performance-based parameters.

The model is then validated and recorded. Model parameters are then compared against historic baseline conditions. If a significant change has occurred, or if the model has drifted from normal range, then a problem is identified.

Similarly, opportunities for process improvement can be rapidly identified, within days of using Active Model Capture Technology. Standard templates for performance can be applied, and generate “trouble spots” within hours. For example, a standard template for Flow Control Loops identifies if process dynamics or variability are outside of the normal range for Flow Loops. If an important flow loop, such as feedwater flow to a boiler, is out of normal range, it is immediately flagged as a loop needing attention.

**Find the Energy Savings in Your Plant**

Now that you know what to look for, you need some tools to sort through all of the data. With a Performance Supervision System, you can gather, all of this information directly from your existing control system.

**Find Needles in a Haystack with the TreeMap**

Using the TreeMap, shown in Figure 6, you can quickly identify where to focus your efforts. The TreeMap is based on public domain technology developed at the University of Maryland. In Figure 6, each control loop is represented by a colored rectangle. The larger the rectangle the more important the control loop. The color of the rectangle indicates the extent of oscillation.

The TreeMap can be easily customized to show whatever performance data you wish to see. In this way, you can quickly find the root cause of any issue in your plant.

For example, set the rectangle size to “Economic Importance” and the color to “Oscillating”, and you will immediately know where to focus your efforts to reduce oscillations.
Process Interaction Mapping

The Process Interaction Map tool, shown in Figure 7, is a way to graphically identify interactions in your plant. Choose any measurement in the plant, and Process Interaction Map will show you which other systems are interacting with it, at which frequency, and to what extent. With a look at this graphic, you will resolve interactions.

Since the Process Interaction Map data is gathered automatically, 24 hours a day, there is no need to establish special studies to gather data, or perform bump tests. You just bring up the display, and see the results.
Figure 7. Identify Process Interactions with Process Interaction Mapping

Keeping it Simple

Looking after a large plant can be quite a challenge. Few people have the luxury of time for extensive analysis. Luckily, the Performance Supervision System has both the power and the intelligence to do most of the front-end work for you.

Today’s powerful software tools can help drive you directly to the solutions. With context-sensitive drill-down capability, clicking on a report or graphic will drive you to the root cause of the problem. Reports and graphics can be automatically delivered to you on a scheduled basis, or you can receive an alert on your cell phone telling you to look at a specific opportunity. Color-coding of reports helps to focus your attention on the right things.
Conclusions

To find energy savings, you must look in the right place, and you must measure the right things. A Performance Supervision System, such as PlantTriage®, will automatically gather the right information from your control system, prioritize, and make it easy for you to pinpoint the biggest opportunities.

References


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For more information about Active Model Capture Technology, or to discuss any of the content of this white paper, please contact George Buckbee, Director of Product Development at ExperTune, Inc. at (262)369-7711 or email sales@expertune.com.

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George Buckbee, P.E. is Director of Product Development at ExperTune, Inc. George holds a B.S. and M.S. in Chemical Engineering, and has over 20 years of direct applications experience in the Process Control field. George is responsible for development of ExperTune’s PlantTriage Performance Supervision System and PID Tuner/Analyzer.