



# Energy Management for Motor Driven Systems

An Online Continuing Education Course for Engineers

**Course Number: E-8001**

**Credit: 8 Hours / 8 PDH / 8 CPD**

# Glossary for Equations

The following variable names are used in equations in this course:

$P_i$	= Three phase power in kW
$P_j$	= Power dissipated in a junction in watts
$P_2$	= Corrected input power
$P_1$	= Input power before correction
$P_{\text{Apparent}}$	= Apparent power in kVA
$P_{\text{Apparent1}}$	= Apparent power before PF correction in kVA
$P_{\text{Apparent2}}$	= Apparent power after PF correction in kVA
$P_{\text{Reactive}}$	= Reactive power in kVAR
$P_{ir}$	= Input power at full rated load in kW
$P_o$	= Actual output horsepower
$P_{o2}$	= Corrected output power
$P_{o1}$	= Output power before correction
$P_{or}$	= Nameplate rated horsepower
PF	= Power factor as a decimal
$PF_1$	= Original power factor
$PF_2$	= Power factor after correction
V	= RMS voltage, mean line to line of 3 phases
$V_{\text{maxdev}}$	= Line to line phase voltage deviating most from mean of 3 phases
$V_j$	= RMS voltage across a junction
$V_r$	= Nameplate rated voltage
I	= RMS current, mean of 3 phases
$I_j$	= RMS current through a junction
$I_r$	= Nameplate rated current
kWh	= Electric energy in kWh
$kWh_{\text{savings}}$	= Annual electric energy saved in kWh
$kW_{\text{billed}}$	= Adjusted or billable demand
$kW_{\text{demand}}$	= Measured electric demand in kW
$kW_{\text{saved}}$	= Savings from efficiency improvement in kW

$kVA_{\text{demand1}}$	= kVA demand before PF correction
$kVA_{\text{demand2}}$	= kVA demand after PF correction
N	= Number of days in billing period
e	= Efficiency as operated in %
$e_2$	= Corrected efficiency
$e_1$	= Efficiency before correction
$e_{\text{std}}$	= Efficiency of a standard motor as operated in %
$e_{\text{EE}}$	= Efficiency of an energy efficient motor as operated in %
$e_{\text{fl}}$	= Efficiency at full rated load as a decimal
Load	= Output power as a % of rated power
S	= Measured speed in RPM
$S_r$	= Nameplate full load speed
$S_s$	= Synchronous speed in RPM
Slip	= Synchronous speed - Measured speed in RPM
hours	= Annual operating hours
$\$_{\text{savings}}$	= Total annual dollar savings
$\$_{\text{demand}}$	= Monthly demand dollar charge
$\$_{\text{energy}}$	= Dollar charge per tailblock kWh
$\$_{\text{premium}}$	= Price premium for energy efficient motor compared to standard
$\$_{\text{rebate}}$	= Utility rebate for energy efficient motor
$\$_{\text{new}}$	= New motor cost
$\$_{\text{inst}}$	= Installation cost
PB	= Simple payback in years
% reduction	= Percent reduction in distribution losses
R	= Resistance in ohms
Unbal	= Voltage unbalance in %

### Introduction

*This energy management course is designed to assist the industrial facility engineer to reduce energy costs through:*

- Identifying and analyzing motor driven system energy conservation opportunities,
- Troubleshooting and tuning the in-plant electrical distribution system,
- Correcting for power factor,
- Understanding utility billing statements, and
- Establishing a preventative and predictive maintenance program.

Why should industrial plant staff work to save energy? One answer is money.<sup>1-1</sup> Ever-increasing utility costs reduce profits, erode capital and maintenance budgets, increase product costs, and reduce competitiveness.

A common misconception within industry has been to equate an energy reduction or conservation program with the concept of turning off equipment and shutting down processes. Instead, the program of energy management challenges plant staff to produce the products or services with the absolute minimum energy consumption.<sup>1-2</sup> The objective is to minimize energy usage through production efficiency gains, while procuring the lowest cost and most reliable supplies of fuel and power.<sup>1-3</sup>

In addition to reduced energy costs and potentially increased

profits, industries that take advantage of energy efficiency opportunities often gain additional benefits such as:<sup>1-4</sup>

- More productive state-of-the-art-technology that improves a facility's competitive edge and improves global competitiveness;
- Improved environmental performance and compliance with environmental and pollution abatement regulations; and
- An enhanced public image as an environmentally friendly or "green" company.

Energy management is not a one-person responsibility or a one-time investment in conservation measures. Energy management is an ongoing effort marked by gradual improvements in energy-efficiency.<sup>1-2</sup> A successful energy management process is marked by:

- Maximizing production efficiency,
- Minimizing energy consumption,
- Maintaining a high energy load factor,
- Correcting for low power factor, and
- Acquiring and using economical supplies of energy.

Energy management does not just happen. Effective energy management occurs when the idea and practices associated with energy management become part of the "corporate culture."

*A rule-of-thumb is one person-year for each \$1 million of annual energy expenditures. As progress is made, the commitment can be reduced to one person-year for every \$2 - \$5 million spent annually.*

## Elements of a Successful Energy Management Program

Energy-management consists of a well structured team effort to create energy awareness: collect and organize energy cost and consumption data; identify, analyze and implement energy conservation opportunities; and monitor results. The program must be accomplished without placing an undue burden on plant maintenance or engineering staff.<sup>1-2</sup>

Ten “Key Elements” that are crucial to success of an energy management program are:

### 1. Secure Top Management Commitment

Top management must be committed to a motor-driven systems energy conservation program.<sup>1-6</sup> To a substantial degree, management’s attitude toward energy conservation will determine the success of the energy plan.<sup>1-1</sup> Management must be willing to provide both personnel and financial resources.

Employees will apply their best efforts to an energy conservation program only if their management displays awareness of the program’s importance.<sup>1-6</sup>

### 2. Appoint an Energy Coordinator

A plant energy coordinator should be appointed to guide energy management efforts.<sup>1-2</sup> The energy coordinator should have an energy background with energy management being a primary duty.<sup>1-7</sup>

The energy coordinator can be likened to a coach: mobilizing resources, providing sound advice, motivating others, and providing support.<sup>1-1</sup> The coordinator should be responsible for energy management activities such as:<sup>1-2</sup>

- Making energy management an integral part of every department.
- Providing operators, foremen, and maintenance staff with tools they need to be part of an energy management team.
- Analyzing trends in energy use and efficiency and identifying areas of concern.
- Informing plant management of roadblocks to energy use reduction while suggesting ways to remove them.
- Stimulating interest in the installation of energy saving measures.
- Assisting in the development of energy use standards.
- Reviewing plans for plant expansions, process modifications, and equipment purchases to ensure that energy is used efficiently.
- Directing the activities of outside consultants, and
- Preparing monthly or bi-monthly facility energy efficiency reports so that management can be continuously updated on motor-driven system improvements, energy savings, and cost reductions.

### 3. Obtain Employee Cooperation

The cooperation of operations and maintenance staff is vital to the success of any energy management effort.<sup>1-2</sup> In most cases, the effectiveness of an energy improvement program is proportional to the effort and time the energy coordinator and department representatives are allowed to spend on it.<sup>1-6</sup> Recognize and support internal “idea champions”. An idea champion is the prime mover: the person with the vision, desire, and persistence to promote a conservation project or approach to see it through to completion.<sup>1-1</sup>

An energy committee should be established, with representatives from each department expected to make recommendations and conduct investigations. Participants in the energy committee help create that “critical mass” that is crucial for success. A sense of “ownership” develops commitment.<sup>1-1</sup> A typical energy management team organizational chart is depicted in Figure 1-1.<sup>1-6</sup>

### 4. Conduct Energy Surveys

An initial plant energy survey shows where and how energy is being used and/or wasted.<sup>1-6</sup> An inventory of energy-using equipment should be prepared, showing basic energy use data (usually obtained from equipment nameplates) and indicating typical running time and operating profiles. Without basic audit information, it is impossible to tell whether equipment is operating unnecessarily or not fully.

*To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.*

*Close this window and click “Add to cart” on the product page.*

Figure 1-1 Typical Energy Management Team Organization Chart

