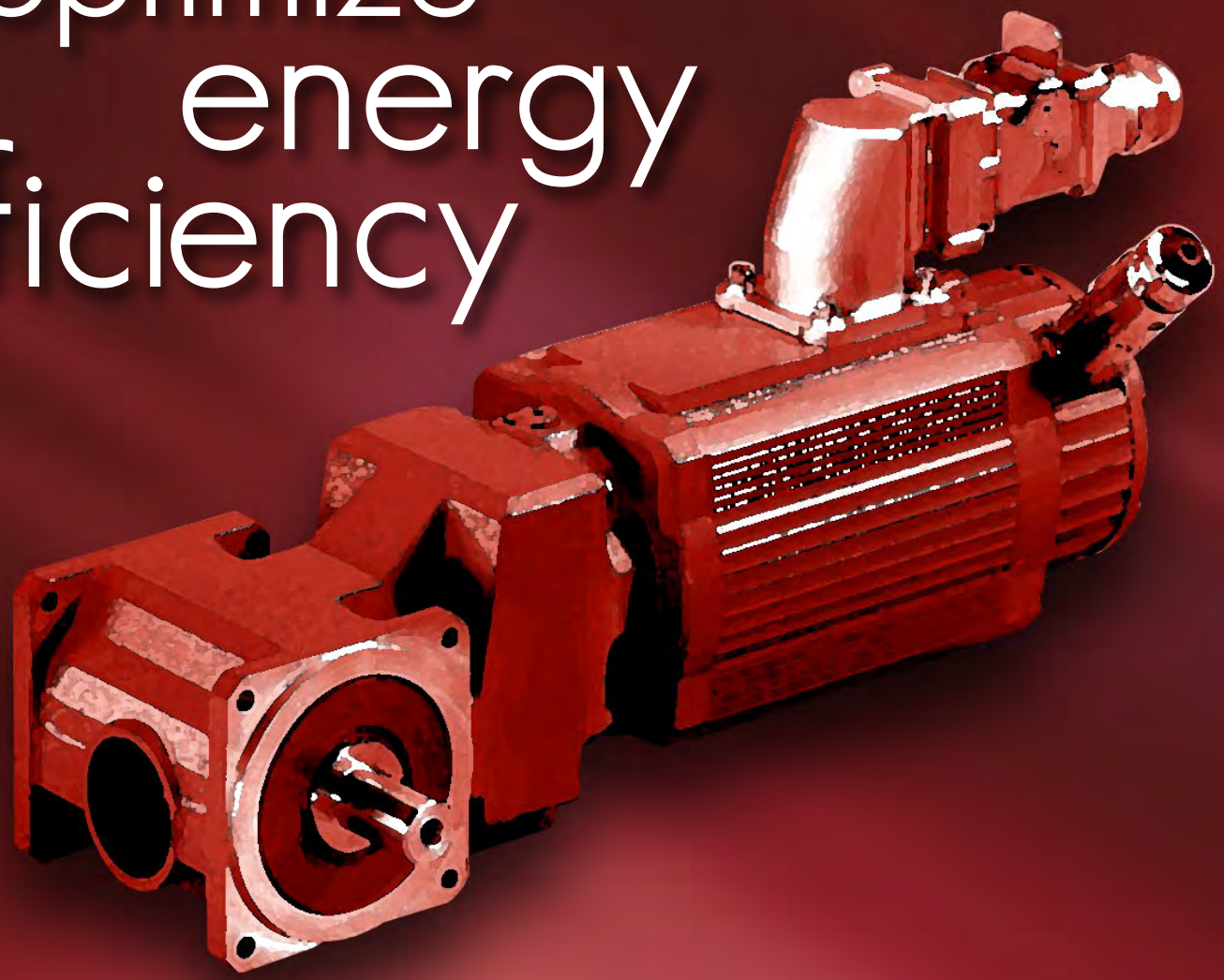
CONTROL ENGINEERING

System designs to optimize energy efficiency



Sponsor Overview

As a world leader in drive technology and a pioneer in drive-based automation, **SEW-EURODRIVE** has established a reputation for quickly solving the most difficult power transmission and motion control challenges. We introduced the gearmotor in 1931. In the 80 years since then, we have been bringing the best in drive technology to our customers. That commitment has led to a history of innovations - the first variable speed gearmotor, early development of electronic drives, some of the first successful efforts to decentralize control, and the first motor with energy-efficient copper rotors. Of course none of that matters without satisfied customers.

Quickly solving problems so that our customers can be more productive and profitable continues to be our priority. We offer the broadest product line in the industry - from gearmotors and heavy industrial gear units to electronic drives, software and complete drive-based automation systems. Our products are based on a unique system of modular components that can be assembled in literally millions of different configurations so every drive solution is custom built to our customer's exact specifications. Our regional assembly centers stock millions of dollars of our modular inventory for quick delivery of drive solutions and spare parts anywhere in the U.S.

At **SEW-EURODRIVE** our expertise doesn't stop with the sale of our products. We offer one of the most accessible customer support systems in the industry. Our trained product specialists are readily available for on-site start up assistance and applications support. In addition, our **PT Pilot®** drive selection quickly selects the drive for your specific needs. Our customer service personnel, engineers, product specialists, and service technicians are available to answer questions and troubleshoot problems. **SEW-EURODRIVE** offers on-call emergency technical support around the clock.

SEW-EURODRIVE brings together everything you need to drive performance for your systems: A superior family of products, unsurpassed engineering, technical support, and innovative new technologies. We invite you to experience the **SEW-EURODRIVE** difference.

Go Beyond Motors to Reduce Energy Use

With energy costs impacting every business, and growing concerns about how burning fossil fuels is affecting the world's climate, companies of all sizes are exploring ways to make their operations more energy efficient. The use of high-efficiency motors would appear to be a logical solution. But motor efficiency does not always equal energy savings.

SEW-Eurodrive

The true potential for saving energy involves a much bigger story, one that requires taking into account the entire power train. That's because an energy efficient motor can reduce energy use by only 10%, even under optimum operating conditions. Far more important in saving significant amounts of energy are the use of electronic speed controls, which can reduce energy use by 30%, and optimizing mechanical systems, which can reduce energy use 60%.

Understanding energy loss

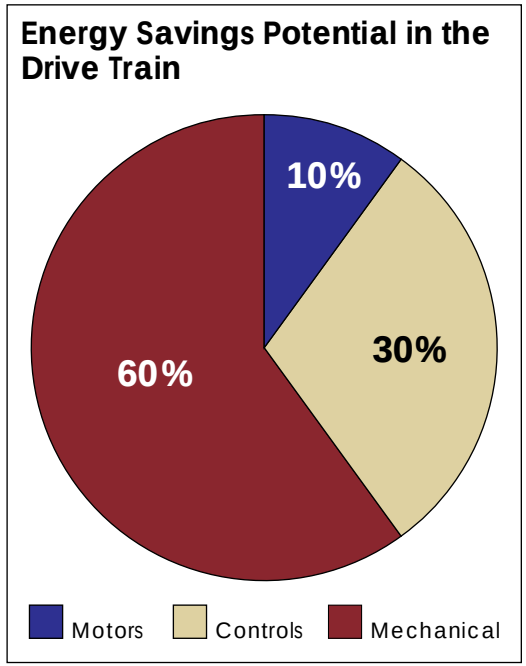
Energy is defined as the work stored in a system or a system's ability to do work. If any of the electrical energy that flows through a system is not actually applied in doing work, then it is wasted. In other words: the more efficient a system is, the less energy is lost.

To calculate how much energy is being lost through system inefficiencies, engineers use the following formula to determine the amount of power (P) introduced into a system compared to the energy output:
Pin – Pout = P loss

So how is energy lost? A typical power train consists of a motor, drive, gearing, and wiring. Energy can be lost from each component. In an asynchronous motor, for example, there are friction, magnetization and ohmic (resistance) losses. Both the design of a motor and the quality of materials used to construct it can contribute to energy losses.

Since each component can contribute to energy loss, let's consider each one individually.

Motors —Major sources of energy loss in motors result from friction in the bearings and seals, wind resistance of the motor fan, iron losses in the forms of hysteresis and eddy currents (based on the quality of sheet metal used to construct the stator and rotor laminations), copper losses (I2R losses), and harmonics.



The low-hanging fruit for energy saving may be mechanical, not electrical.

Improving the energy efficiency of motors can be achieved by using better materials with lower resistance, such as rotor cages of copper instead of aluminum. Motor efficiency can also be improved by increasing the size of the active components of the motor. This is why premium-efficiency motors have higher inertia rotors. But be careful here— while it may be tempting to use motors with higher horsepower ratings than your ap-

plication calls for simply because their nameplate efficiency is higher, that efficiency is based on full-load operation.

A 10 HP motor may be listed as being more efficient than a 5 HP motor, but it will use a lot more current. And a partially loaded motor is terribly inefficient. A good rule of thumb is to operate motors in the 80% to 90% utilization range for optimal efficiency. The use of VFDs (variable frequency drives) allows you to slow the motor down to keep the utilization at its optimum.

Wiring —Electric cables produce both ohmic and capacitive (energy storage) losses. Ohmic losses in the conductors are inversely proportional to the diameter but are proportional to the length. With standard designs, total power losses on the cable can amount to as much as 5% of the transferred power. Shorter cables with larger diameter conductors minimize energy losses.

Gearing —Losses in gearing are due primarily to friction caused by movement between the teeth. Worm gears, for example, are the least efficient type of gearing because they experience a great deal of sliding and therefore generate significant friction.

Lack of sufficient lubrication is another source of friction and resulting energy loss. Incorrect mounting positions, temperature, and immersion depths are the key factors here. The flow of the oil is determined by its temperature and viscosity. The thicker the oil, the more torque is required to move the gear. The higher the oil temperature, the thinner the medium will be and the lower the power loss. The design of the housing also determines the arrangement of components, and therefore the oil flow.

Bearings and oil seals also have a part to play in energy-efficient operation. Gear unit efficiency is influenced by the seal between the motor and gear unit as well as by losses in the gear unit. The higher the input speed, the higher the losses in the bearings and churning losses in the oil.

Inverters —While inverters or variable speed drives are often added to a power train to reduce energy consumption, they also consume electricity in operation. A drive's contribution to energy savings lies in its ability to allow you to manage motor operations to reduce output power. Managing motor speeds, ramps, and available torque translates directly into managing power consumption.

Improve system efficiency

In designing for energy efficiency, it is critical to take a holistic view of the system or process. When several machines or components work in series as a system, then their individual efficiency ratings must be multiplied to arrive at the overall efficiency rating.

For example, while a premium-efficiency motor has an efficiency rating of roughly 95%, the efficiency of a worm gear is between 50% and 80%, depending on the make and model. Using a premium-efficiency motor with worm gearing would therefore be counterproductive, since the system's overall efficiency rating would be closer to the gear-

ing than that of the motor.

An understanding of the application is equally important in component selection. High-efficiency motors are designed to reduce power consumption in continuously running operations, such as fans or pumps. Therefore, they usually have heavier rotors than standard motors, which enable them to take advantage of inertia once they are started. But in applications where motors run intermittently, with frequent starts and stops, the heavier (often larger diameter), high inertia rotors can become real energy burners, as it requires more energy to start these high-efficiency motors.

Now think about the equipment at your site, such as sorters, pushers, indexers that are typically found in airports and parcel handling systems. Or applications such as conveyors in automotive plants, out-feed conveyors on packaging machines, or large packaging machines like palletizers and pallet wrappers. Motors powering high-cycling applications like these may only run at full speed for a few seconds, but they are in start-up mode much of their lives. For these applications, motors with lower inertia rotors will use much less energy.

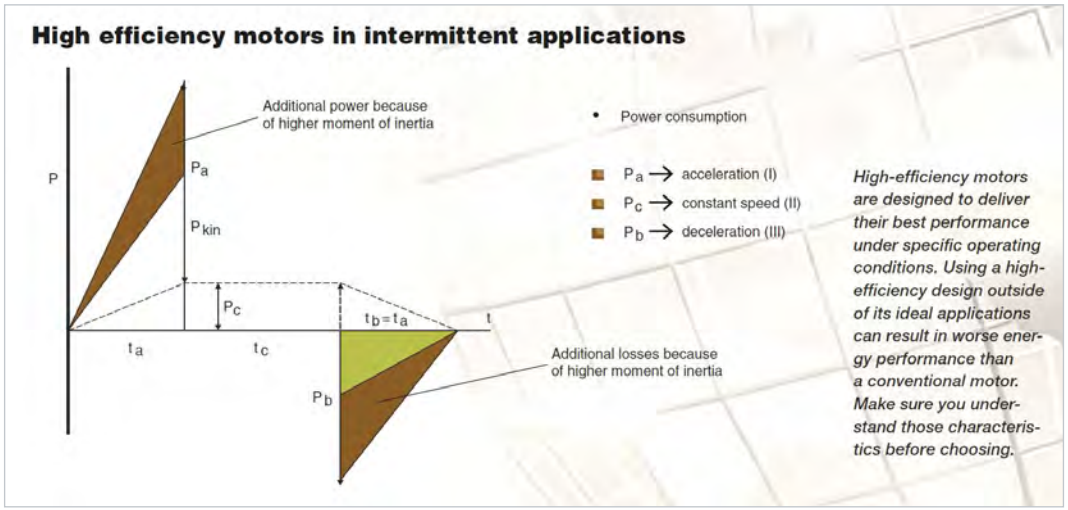
Application-oriented engineering

Different applications require different engineering solutions to reduce power losses and consumption. The following examples represent just two approaches to saving energy.

Conveyors —Many conveyor systems, like those used in automotive assembly, packaging or baggage handling are powered by a combination of components that include a NEMA-frame motor, an external clutch brake, reducer, V-belt, and pulleys. The high inertial factors involved in this design approach and the repeated shaking of the equipment every time the clutch is engaged place a severe strain on components. Reducers and clutch brakes must be replaced frequently, resulting in downtime and energy consumption rates that are unacceptable.

While a single start/stop cycle might use only a fraction of a second of energy, some of these applications may involve thousands of cycles per hour. When compounded monthly or yearly, the impact on energy usage and heat damage to components is significant.

A more efficient alternative to this



High-efficiency motors are designed to deliver their best performance under specific operating conditions. Using a high-efficiency design outside of its ideal applications can result in worse energy performance than a conventional motor. Make sure you understand those characteristics before choosing.

cumbersome drive train design is an IEC-type gearmotor with an integral brake, a shaft-mounted helical bevel gear reducer and a VFD. This streamlined system reduces maintenance, parts and energy usage, while equipment uptime is increased.

Storage and retrieval —In a vertical storage and retrieval system, like those used in a manufacturing plant to manage parts inventory, one drive handles the travel axis and another controls the hoist axis. Since energy is proportional to mass x height, items stored in the rack have associated potential energy. This energy is released when the load is lowered.

Also consider the kinetic energy in the motion of the horizontal carrier. What happens to this energy when this high- horizontal load is decelerated? With conventional control, the released energy of both axes is dissipated using braking resistors, resulting in significant power loss. A more energy-efficient solution is to tightly coordinate the timing of the motions of the two drives using a programmable controller. This allows the regenerative energy produced during the braking operation of one drive to be diverted to power the motion operation of the second drive.

By taking advantage of this regenerative power sharing, total energy consumption falls dramatically, in the range of 25% to 40% depending on the system, without reducing system dynamics or cycle time.

Focus factors for efficiency

Designing for energy savings requires reducing both power losses and power consumption.
Following are the five key factors to focus on to reduce power losses:

- Increase gear unit efficiency;
- Increase motor efficiency;
- Eliminate unnecessary functions;
- Use/recycle released energy by direct utilization, regeneration of braking energy and energy storage; and
- Size components according to demand.

In addition to reducing power loss, engineers should also focus on reducing power consumption to address both portion of the power loss equation. Here are the four critical power consumption factors:

- Reduce/control output speeds;
- Reduce load torque through rigid transmission components, counterweights and minimizing friction;
- Use of energy-saving modes; and
- Turn the device off.

The bottom line is that there is no single solution for saving energy when it comes to motorized systems. Each component of the drive train offers opportunities to improve efficiency and reduce power losses. These opportunities vary by application, as does the engineering solution required. Being energy smart will require rethinking old assumptions and practices. Above all, it will mean engineering for energy savings in every system, every machine, and every process.

IBM forms Green Sigma Coalition
Creating a unique arrangement with its metering, monitoring, data communications, and automation partners, IBM rallies its technology resources to to provide smart solutions for energy, water, waste, and greenhouse gas management.
http://www.controleng.com/index.php?id=483&cHash=081010&tx_ttnews[tt_news]=18216

Energy Efficient Motion

Cost of energy to run many motors over their lifetimes is much more than the actual capital cost of the motors themselves. So if energy efficient motors cost so much less in the long run, why don't more people buy energy efficient motors?

Mark T. Hoske, Control Engineering

1. They cost more upfront.

2. End-users may not realize or directly benefit from the lifecycle savings (capital cost of the motor plus energy cost to run the motor). The person in charge of the capital budget for equipment may not be the same person in charge of energy usage. Minimizing capital expenditures to spend more on energy may be the equivalent of saving a dime and losing a dollar (or more in scale, saving a few thousand dollars now and losing tens of thousands of dollars over time or a few years). In some applications, electricity can cost 100 times the capital cost of the motor over its life, some sources say.

3. Those specifying the motors for use in machinery or equipment fear that customers won't accept the slightly higher related capital costs involved and select a competitors' design that costs less upfront, but much more over the equipments' useful life. Various motor manufacturers, electric utilities, consultants, system integrators, savvy original equipment manufacturers (OEMs), policymakers, and legislators see opportunities to educate, encourage, and provide appropriate incentives for more energy efficient motor use. While that may be the most direct or obvious means of energy savings, it isn't the only one.

Opportunities for savings

In a motion-based system, opportunities for efficiency include avoiding motion, using less motion, and kinetic energy recovery. Simply put, improving efficiency might mean:

- Simplifying workflow to in clude fewer steps or handling something fewer times, so fewer motors are needed. Just-in-time initiatives can address that point.
- Using variable speed drives that can run motors at a speed ap propriate to an application, rather than wasting energy by running the motor a full speed and then wasting heat through gearboxes, braking, or damping to control speed.
- New drive design: newer motor drives save energy using technolo gies that better manage voltage and power, optimizing onboard parameters to best-suit applica tion needs. If the accompanying machine has water cooling, that also can be used to cool onboard motors and drives. Direct drive design is more efficient than a transmission.
- Regeneration, often used on very large industrial motors, creates energy by using the motor as a generator to absorb kinetic en ergy, instead of dissipating energy by applying a brake.
- Sizing changes. Engineers' con servative tendencies may be to specify a motor and drive combi nation (or equipment in which they operate) one size larger. Doing so may waste electricity over time by running outside of the optimal band of efficiency for the actuator or the equipment in use.

U.S. Department of Energy says motor-driven equipment accounts for 64% of the electricity used in the U.S. industrial sector. Approximately 95% of an electric motor life cycle cost revolves around energy consumption, and those purchasing

motors understand advantages of higher efficiencies. The U.S. National Electrical Manufacturers Association (NEMA) reported in 2004 that unit shipments of premium efficiency motors increased about 30% from 2001 to 2002, and another 14% from 2002 to 2003. NEMA continues to advocate for measures that encourage use of more energy efficient motors.

In May 2007 testimony to the U.S. House of Representatives' Committee on Energy and Commerce's Energy and Air Quality Subcommittee, NEMA president and CEO Evan Gaddis recommended that the Energy Policy and Conservation Act be further amended to give DOE authority to conduct an expedited rulemaking if submitted as a "consensus proposal." The recent American Council for an Energy Efficient Economy (ACEEE)/NEMA consensus recommendations would accelerate the DOE timetable by three years to achieve savings for integral 1 hp to 200 hp motors as early as 2011, and would greatly increase the scope of federally-covered products.

In April, NEMA testified before the Senate Energy and Natural Resources Committee about pending legislation, S 1115, "The Energy Efficiency Promotion Act of 2007. NEMA "stressed the need for

	Full-load motor efficiency (%)		Annual savings	
Horsepower	Original efficiency	Final efficiency	Annual energy savings, kWh	Dollar savings, $/yr
10	89.5	90.5	605	$30
25	92.4	93.4	1,420	71
50	93.0	94.0	2,803	140
100	94.5	95.5	5,431	272
200	95.0	96.0	10,748	537

Assumptions: 1,800 rpm enclosed fan-cooled motor with 8,760 hours per year of operation, 75% load, and an electricity rate of $0.05/kWh.
Source: Control Engineering and industrial Technologies Program, Energy Efficiency and Renewable Energy, U.S. Department of Energy, www.eere.energy.gov/industry

Congress to expand and extend energy-efficiency tax provisions as it shapes the overall legislative energy package" to remove "one of the barriers to deployment of today's energy efficient products: their initial cost." There's "fierce competition for limited investment dollars," NEMA says. And as more efficient motion technologies are used, more dollars will be freed for other investments.

ONLINE EXTRA: Energy efficient motion products and resources

Other useful links for energy efficient industrial motion follow.

- Comparative analysis of IEEE 112-B and IEC 34-2 efficiency testing standards
- IEEE Find a standard
- DOE estimate motor efficiency (PDF)

Other energy efficient motion Control Engineering coverage includes:

- NEMA call includes promotion of energy efficiency.
- SPS/IPC/Drives 2006: Motion, mechatronics, efficiency
- Silicon carbide (SiC) power module enable energy savings
- New technology boosts energy efficiency of single-phase motors
- Energy-Efficient Motors Deliver Savings

In simplest terms, energy-efficient electric motors are high-quality versions of standard motor products. They pack more of "active" electric materials (steel laminations and copper) into essentially the same physical package—hence carry a price tag 15-30% higher than their less-efficient cousins.... Article includes summary of related laws, agreements, and standards.

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Motor sizing and efficiency resources

MotorMaster+ Version 4.0.6 , released by U.S. Department of Energy (DOE) in March, updates the DOE's Industrial Technology Program's energy-efficient motor selection and management tool. The software includes a catalog of over 20,000 ac motors, along with motor inventory management tools, maintenance log tracking, efficiency analysis, savings evaluation, energy accounting, and environmental reporting capabilities. It has a checkbox to display only NEMA Premium motors in the MotorMaster+ List, addressing the requirement for federal government agencies to purchase only NEMA Premium motors. A similar option limits batch analysis setup to NEMA Premium for purchase of replacement motors. The version also updates motor price and performance data for Reliance, Baldor, and Siemens motors.

MotorMaster+ International 1.0.15 offers to evaluate repair / replacement options on a broader range of motors, including those tested under the Institute of Electrical and Electronic Engineers (IEEE) standard, and those tested using International Electrical Commission (IEC) methodology. Varied currencies and languages are available. Look under software tools at

NEMA Premium energy efficiency motors program aims to provide highly energy efficient products to meet the needs and applications of users and original equipment manufacturers (OEMs) based on a consensus definition. NEMA has been working with American Council for an Energy Efficient Economy (ACEEE) to advise Congress.

NEMA Premium energy efficiency specification free download.

ComponentSelector , a "motion-intelligent expert system" from MotionInfo.com and Incremotion Associates, helps optimize size, performance, and anticipated cost.

DOE Industrial Assessment Centers (IAC) Database is a collection of all the publicly available assessment and recommendation data. This includes information on the type of facility assessed (size, industry, energy usage, etc.) and details of resulting recommendations (type, energy & dollars savings etc.). As of May 2007, the IAC database contains: 13,453 assessments and 99,714 recommendations. Among recommendations, using energy efficient motors ranked 24th. Look under best practices at

Cover story: Energy-Efficient Electric Motors

How to get the most out of energy-efficient motors: You have to do more than just look at the motor nameplate to get maximum energy savings. Are you ready for Dec. 19, 2010, the next major U.S. motor efficiency compliance deadline? Those truly interested in increasing efficiency will take a holistic view of overall machine design. Here's how to get inside motor efficiency to maximize savings.

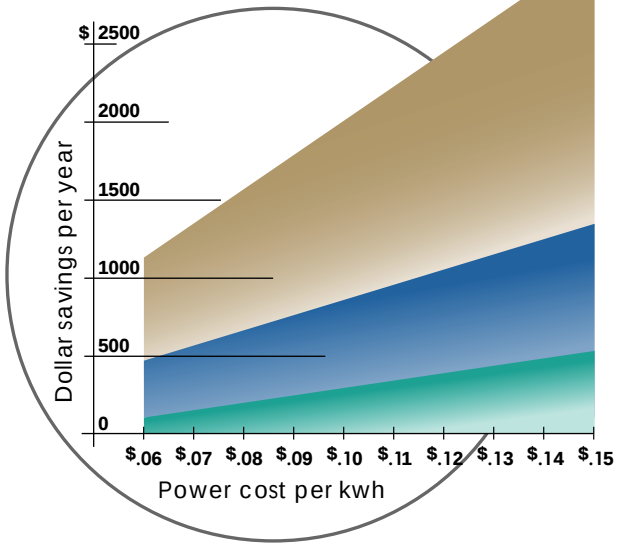
C.G. Masi for Control Engineering

Concern for the environment may motivate private individuals and the general public, but it's a poor reason for making business decisions. Companies buying and installing electric motors have a far better business reason for trying to save electricity— making their operations more cost-efficient. In a rare confluence of factors, reducing electricity usage by installing more energy-efficient electric motors promotes both of these goals. And, it might be a requirement as of Dec. 19, 2010, the next major U.S. motor efficiency compliance deadline.

When one talks about high-efficiency motors, it is important to note that this term really refers to traditionally architected electric motors consisting of armature and field windings. "Induction motors are available in standard-, high- and premium-efficiency models," said David Hansen, global product manager, Kinetix Motion Control, Rockwell Automation, "whereas permanent magnet motors are not."

The reason is that the permanent-magnet electric motor architecture is inherently more efficient, since no power is used to establish the stator magnetic field. John Malinowski, senior product manager - ac motors, Baldor Electric Company, pointed out: "ac induction motors have a family of motors that comply with NEMA Premium Efficiency per NEMA MG 1, tables 12-12 and 12-13,

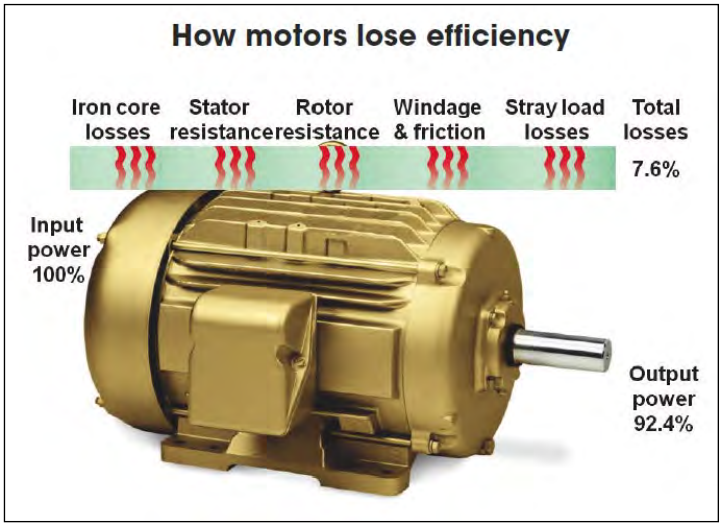
Higher-efficiency Motors Run Up Energy Savings



Higher-efficiency motor savings can add up quickly. The chart, provided by Baldor, shows savings from using a 94.5% efficient motor versus an average industrial motor at 88% efficiency.
Source: Baldor and *Control Engineering*

and IEC 60034- 30 [standards] for IE3 efficiency."

For that reason, we limited this discussion to induction motors having stator coils wound on ferromagnetic cores, and save looking at the energy-efficiency characteristics of permanent magnet motors for a later discussion.



"Premium motors," Malinowski continued, "are built to closer tolerances than older motors, run cooler, have less vibration, are quieter, and last longer."

However, "high efficiency in today's ac induction motors," said Peter Fischbach, industry sector manager, Bosch Rexroth Corp., "is achieved by improving the energy conversion paths and physical properties with new slot and winding geometries, advanced magnet and core materials, and the use of copper rotors for ac induction motors."

What makes a motor efficient?

"The key to higher efficiency is reducing losses," Malinowski said. "More copper in the winding to reduce stator losses, and higher-grade electrical steel reduces iron-core losses. Lower losses mean fewer watts to cool so smaller fans can be used, [further] reducing losses."

Fischbach added: "The majority of the losses are caused by conductive losses in the stator and rotor and core losses, also called iron or hysteric losses."

Hansen listed a number of design features that give these motors their high efficiency:

- **Winding Resistance**—As winding resistance increases, efficiency decreases. To maximize motor efficiency, motor designers minimize resistance by maximizing slot fill (amount of copper windings in the stator slots) and minimizing end-turn radius (amount of copper windings outside the stator slots).
- **Lamination Material**—Core losses are directly influenced by the material properties and quality of the steel used in the stator laminations. In addition, thinner laminations will lead to lower core losses in the stator than thicker laminations.
- **Lamination Tooth Geometry**—Lamination tooth geometry impacts concentration of the magnetic flux inside the motor. Geometries that provide higher magnetic flux concentration will have lower stray losses and therefore higher efficiency.

It's the system that counts

"The goal in most factory automation and industrial applications," Fischbach suggesteded, "is efficient use of energy with the highest productivity. Therefore it is essential to analyze, model, and optimize the complete system before investing in individual components, like new motors."

Malinowski agreed: "Better motors

Motor efficiency deadlines for European Union

"In June 2011, Lenze says, minimum degrees of efficiency for three-phase ac motors will be introduced in the EU for:

- 2-, 4-, 6-pole three-phase asynchronous motors, 0.75 to 375 kW
- 50 Hz and/or 60 Hz
- S1 – continuous operation
- Geared motors and motors operated by an inverter"

Switchover date	Power	Minimum efficiency
Jun. 16, 2011	0.75 to 375 kW	IE2
Jan. 1, 2015	7.5 to 375 kW	IE3 or IE2 + frequency inverter
Jan. 1, 2017	0.75 to 375 kW	IE3 or IE2 + frequency inverter

IEC/EN 60034-30	Europe	USA
IE1	eff2	NEMA Energy Efficiency
IE2	eff1	NEMA High Efficiency
IE3	—	NEMA Premium Efficiency

Not included are motors outside the rating frequencies above, and explosion-proof motors under ATEX.

Source: Lenze and Control Engineering; *For more information, see the BlueGreen area of www.lenze.com under ErP directive for energy-related products.*

are easy to do as drop-in replacements [for less efficient units] but efficiency gains are limited. Using a 95% efficient motor is good but not when connected to a double-reduction [geartrain] that is 50% to 60% efficient, when a helical or bevel speed reducer may be 90% to 95% efficient."

Fischbach also concurred: "Higher efficiency is a relative term there since we also have to consider other factors [that] affect the overall system efficiency, like cycle time or product output. For example, a direct drive torque motor with 80% efficiency could save more energy than a 95% efficient servo motor by eliminating inefficient drive train elements like gear boxes—and significantly increase production, too."

What not to do

"The biggest mistakes," Fischbach warned, "are made by engineers just focusing on the name plate efficiency of the motor, and expecting similar percentage energy savings in their specific application.

Different motors have different characteristics, which have to be matched to the application to benefit from the investment in a higher efficiency motor. For example, a more expensive premium efficiency ac induction motor will not save much energy if it's run at partial load or idling for long periods of time."

Malinowski provided the example of replacing a much older motor with a new premium motor on a centrifugal pump. The impeller would have been sized for the old motor's speed. However, the new, more efficient, motor likely will run faster under the same load, leading to more overall power use. The system might be more energy-efficient, but the additional work it does may not provide any benefit.

"Designers who are truly interested

in increasing efficiency," advised Hansen, "will not simply look to replace a motor, but will take a holistic view of the overall machine design. Even a perfectly efficient motor, if connected to a poorly designed mechanical system, will not produce significant benefits with respect to energy savings. Any mechanical power transmission device between the motor and the load will have inherent inefficiency. The highest precision helical planetary gear heads, brand new out of the box, are at best 90% to 95% efficient. Worm gear boxes can be as little as 50% to 60% efficient."

"The ultimate solution in terms of machine efficiency," he concluded, "would be to eliminate the mechanical power transmission devices altogether through the use of direct drive permanent magnet servo motors."

Do you buy or specify energy-efficient motors? How does the Dec. 19 motor efficiency deadline affect you? Take the Control Engineering Energy-Efficient Motors Survey, and share advice, as the Dec. 19, 2010, compliance deadline for the U.S. Energy Independence and Security Act of 2007 (EISA) approaches.

Other resources:

NEMA HE motor standard: www.nema.org/stds/mg1.cfm

IEC HE motor standard: http://bit.ly/aHxTy6

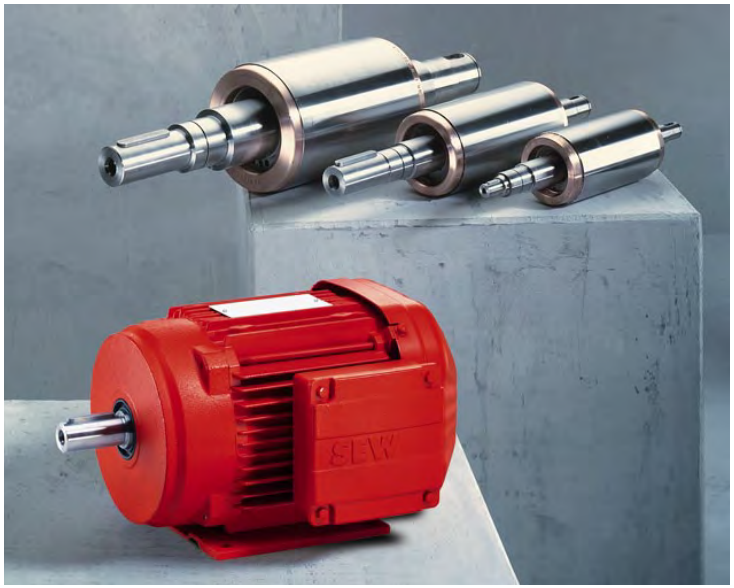
U.S. Department of Energy, Energy Efficiency & Renewable Energy, Industrial Technologies www.eere.energy.gov/industry/

More energy efficient motor reading

Brushless PM Torque Motors - Electric motors come in a rich variety of configurations to suit different purposes. One specialty motor type—known as a direct-drive, permanent-magnet (PM) torque motor—is characterized by a large diameter-to-length ratio and large number of magnetic poles to optimize torque production.

EC: DR Motor

Motion Control - motors: SEW-Eurodrive Inc., DR Motor. SEW-Eurodrive's new modular DR motor system offers more efficiency, performance and pricing options for gearmotors or stand-alone models. This is a Control Engineering 2011 Engineers' Choice (EC) Award winner.



The modular DR motor is well suited for most any industry. It allows users to specify exactly those options needed for any given application. Users in food, beverage, water and wastewater will find that the coating and sealing options protect these motors in wet environments in a wide range of temperatures. Automotive manufacturers rely on the many connector options to save time and ensure accuracy in installation and replacement. The variety of sensor and feedback options for speed, position and even brake wear are perfect for sophisticated electronic drive control systems found in packaging and logistics applications. Maintenance-friendly modular brakes, encoders and other options make retrofits and other field adjustments simple and fast.

The DR motor offers choices in efficiency levels to meet US and overseas standards. For instance, the DRP Premium Efficiency model meets EISA 2007 and NEMA Premium standards for the USA as well as other energy standards in Canada, Europe, Australia and more. In addition to energy efficiency options, the DR motor also offers other customizable options, including brake size, cost-optimized encoders and mounting type.

Brakes: Inverter driven motors often don't require large brakes. To take advantage of this, up to three brake size options are available for each motor size. The ability to specify the brake size ultimately results in greater cost savings for the customer.

Encoders: The new built-in encoder is fully integrated into the motor, making it more compact and less expensive. The encoder is installed between the endshield and the fan and is connected at the terminal box, so it can be easily retrofitted. Traditional HTL, sin/cos, or absolute mounted encoders are also available for high-precision applications.

Mounting: The motor can be supplied as a gearmotor, foot-mounted and/or flange-mounted with numerous through-hole or tapped-hole configurations. A NEMA C-face flange is also available.
www.seweurodrive.com
www.sewmotortruth.com

SEW-Eurodrive Inc.
For more, see
www.controleng.com/awards.

The Truth About Energy-Efficient Motors

Everyone wants to save energy. Not only does it save money, but it's also the "green" thing to do. And if you are in the market for a motor, the government may even pay you to replace your inefficient motors with new, energy-efficient NEMA Premium® versions.

So, you might think that buying a premium-efficient motor is the answer to your energy usage problems. If so, you are overlooking an important fact: **an energy-efficient motor is only one part of the energy savings equation.** While premium-efficient motors certainly do help to reduce energy usage, they are by no means the cure-all.

For the maximum energy savings, it's important to look at the entire drivetrain. Understand the misconceptions that surround energy-efficient motors and be sure that you are investing your money wisely.

Common Energy-Efficient Motor Misconceptions

1. Efficiency automatically equals savings.

Not necessarily; it depends on the application. The Department of Energy certifies that a motor meets the "Premium" standard established by NEMA, based on that motor's ability to meet a certain efficiency level. And, that level is typically based upon 80-100% loading with the motor connected to constant power source (i.e. across the line). So purchasing a NEMA Premium motor from one manufacturer will very likely give you a motor with basically the same efficiency as a NEMA Premium motor purchased from another manufacturer.

But if you install just a premium-efficient motor, you are not automatically saving all the money you could be saving. There are multiple reasons why this might be possible, as discussed below:

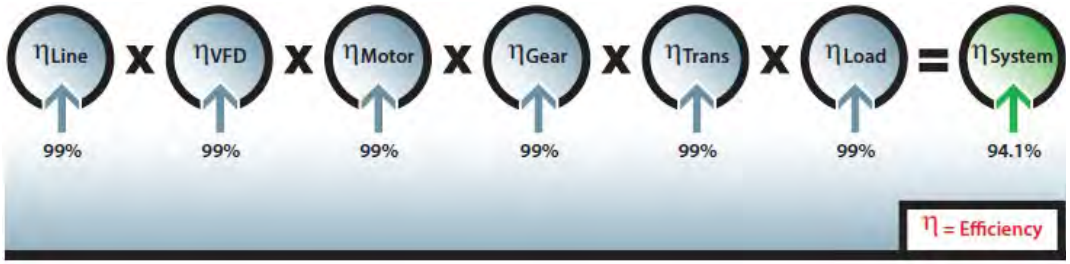
- Your new motor may only be a few percent more efficient than your previous motor. Therefore, in cycling or intermittent duty applications, the savings you recognize are so small that they are outweighed by the higher cost of the new motor.
- Your new motor may not be well-suited to saving energy in your type of application, e.g. high-cycling applications.
- Your new motor may be oversized for the application, yielding much less efficiency than what the nameplate says.
- Other parts of your drivetrain may be much less efficient, causing higher-than-necessary energy consumption from your efficient motor.

While a premium-efficient motor is important, it's critical to evaluate your entire drivetrain for efficiency and to realize that the motor is just a single part of the overall equation.

2. Replacing my motor will give me the best bang for my buck.

It depends. Because a motor is only one component in the drivetrain (and, truth be told, motors for some time have been comparatively efficient). Each component in a system will inherently have some inefficiency, and these energy losses multiply together to provide an overall system efficiency. Just one component with poor efficiency will quickly drag down the rest of the system. Consider the following theoretical example where every component has an almost-impossible efficiency of 99%:

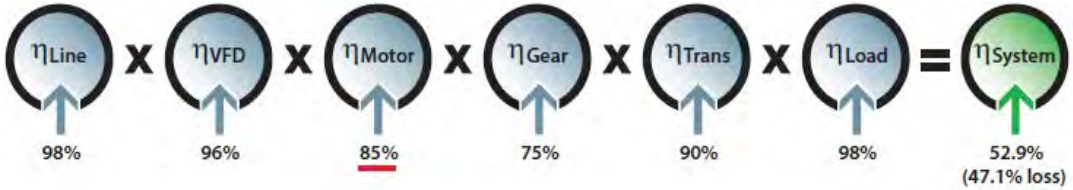
System Efficiency: Ideal Scenario



You'll see that even in this example with 6 components of ideal efficiency, you are still losing almost 6% of the energy.

Now, consider two more realistic examples:

10-Year-Old Motor



New, Premium-Efficient Motor

Motor Savings: 92-85=7%
System Savings: 57.3-52.9=4.4%

You can see in both examples that you are losing over 42% of the energy going into the system. You can also see that replacing your motor with a premium-efficient model will save you just over 4% efficiency, even though the new motor is 7% more efficient than the old motor.

That's because the other, less efficient components in your drivetrain are still wasting energy. So, the investment you've made in a premium-efficient motor will take longer to recoup than you had planned.

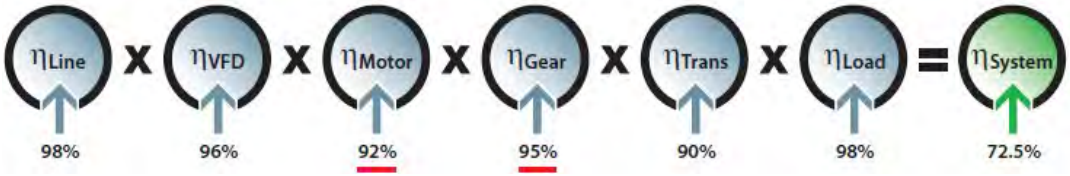
3. Replacing my motor will automatically make my line more efficient.

Well, yes – but by less than you might expect. However, replacing some of the other components along with your motor can provide some very substantial efficiency gains.

Consider, for instance, that you replace the gear unit as well as the motor. Worm gear units, which are installed in most manufacturing environments, are inherently inefficient, as the gears are essentially sliding against one another causing heat (energy loss).

Sure, there are instances in which worm drives are necessary for the application (e.g. withstanding heavy shock loads, or providing back-driving resistance). But in many applications a helical-bevel gear unit, which operates with rolling contact, will be much more efficient.

So, take the previous "real world" example and replace both the motor AND the gear unit.



Now, you are quickly recognizing substantial, double-digit efficiency gains – nearly 20% – and your line begins to become much more efficient.

To gain even more efficiency, consider changing or eliminating your transmission elements. Replace a v-belt with a direct drive. Or, use a shaft-mounted gear unit. Shaft-mounted units, such as the TorqLOC® from SEW-EURODRIVE, offers a keyless, taper hollow shaft with a shrink disc that has a liberal tolerance so it installs easily and can even retrofit onto an existing keyed shaft.

4. A premium-efficient motor is an appropriate energy-saving choice for all applications.

Again, it depends. Most premium-efficient motors used in continuously-running applications will begin to show at least modest energy savings (depending, as previously shown, on the other elements in the drivetrain).

But motors used in high-cycling applications may never recognize the entire efficiency gain of a premium-efficient motor, partly due to the start-and-stop nature of the application fighting against the higher rotor inertia of many premium-efficient motors. Hence, the extra investment in a high-efficiency motor may not ever be completely recouped.

However, some NEMA Premium motors, such as the new DRP motor from SEW-EURODRIVE, are engineered to make them more efficient in high-cycling applications. These motors are designed with low rotor inertia, low losses, and less heat accumulation in the windings, which increases efficiency and provides a very high number of starts and stops per hour.

Be sure that you consider all the options available to you, and be careful to choose the premium efficient motor that is best suited to your need.

5. Adding a variable frequency drive (VFD) will automatically make my line more efficient.

Heat and high-cycling motors

Starting a motor produces a great deal of heat in the windings. This heat is proportional to the current required to start the motor. In many premium-efficient motors, the starting current is much higher than in standard efficiency models. Unless this heat is removed in some way, it will build up and cause motor failure.

Once a motor is started and running, the fan moves air across the motor windings to cool them sufficiently. But, if the motor is stopped before this happens, the heat dissipation process takes much longer. In high-cycling applications, the frequent starts produce a great deal of heat, and the poor air circulation rapidly leads to heat build-up. A motor's ability to manage this heat is what determines the allowable number of starts, or cycles, per hour.

Maybe. As the efficiency equation shows, a VFD is a load. It produces heat (losses) from electricity conversion, switching frequency, and harmonics. So by itself, it will **decrease** your system efficiency. And, what's more, many VFD's have an adjustable carrier frequency that reduces audible noise during operation. Unfortunately, when the carrier frequency increases, so does the heat. In fact, the heat produced at a high car-

rier frequency can be so significant that a room full of VFD's may require a substantial increase in air conditioning.

Thus, the key to energy savings is to use a VFD to reduce other losses in the system (i.e. smart control), as in the following applications.

- **Regenerative Energy:** When a motor is trying to stop a high inertia load or lower a load, it acts as a generator. All of the kinetic or potential energy stored in the machine has to be removed. Typically, it is wasted as heat through a braking resistor. But a regenera tive VFD can put the energy back onto the grid. Some even allow the energy to be directly given to another VFD as it accelerates, such as in a storage retrieval system.

- **HVAC:** Typical systems used in HVAC contain mechanical dampers with motors that run continuously. Using a VFD to turn off the motor or to reduce the motor speed is much more efficient, especially since the load decreases more than four times at half the speed!

- **Soft Start:** Using a VFD to control the acceleration on a cycling application lowers the motor starting current. So, the motor runs cooler since less energy is converted to heat.

- **Motor Efficiency Correction:** Motor nameplate efficiency is usually rated at 80% loading. Therefore, when a large motor is applied to a small load (e.g. 1 HP used instead of 0.25 HP), its actual efficiency decreases considerably. Using a VFD with vector control (or VFC technology) optimizes the motor efficiency, regardless of the loading conditions.

The bottom line? If properly used, VFDs can have some big efficiency benefits when added as part of a complete drivetrain efficiency solution.

The Truth About Energy-Efficient Motors

1. The motor is only part of the efficiency equation.

As you have seen, a motor is at best one-sixth of the total energy loss potential for an electro-mechanical drivetrain. And, what's more, it typically isn't even the most inefficient part. Mechanical devices, such as external transmission elements, have far more inefficiencies than do electrical devices. So, look there first to find your largest energy savings.

2. By revamping your entire drivetrain, you may actually be able to use a smaller motor and save even more.

Right now, you are probably using a motor of a particular horsepower to produce a certain output from your drivetrain. You may be pleasantly surprised to find that, by upgrading your gearbox, drive, and external transmission components, you will have gained enough efficiency that your motor power is now higher than you actually need. Therefore, you may be able to save additional costs by purchasing a lower horsepower motor. For example:

before: 50 HP load ÷ 53.5% efficiency = 93.5 HP (use 100 HP)
after: 50 HP load ÷ 72.5% efficiency = 69 HP (use 75 HP)

3. Motors are most efficient when integrated with other drivetrain components from the same manufacturer.

Systems where the VFD, motor, and gearbox are all engineered by the same company are by nature designed to work well together, eliminating unnecessary inefficiencies and allowing additional energy savings. For example, integrating an SEW-EURODRIVE DRP motor, helical-bevel gear unit, and VFD will provide dramatically higher energy savings than simply replacing the motor.

SEW-EURODRIVE DRP NEMA Premium motor

- High performance 1 – 50HP
- Handles 1000-2000 cycles/hour
- Optional built-in encoder
- Integral brake available in 3 sizes
- Compact integral gearmotor
- Available with NEMA C-flange
- Rated for severe duty environments
- Meets all global efficiency standards

4. The motor must be well-suited to your application.

Just placing a premium-efficient motor on the line may not automatically solve all your energy problems, even if all the other components are as efficient as possible. Ensure that the specifications of the motor fit your application, especially if you have a high-cycling application that is greater than 10 to 30 cycles/hour. If so, use a premium efficient motor designed for such an application with an appropriately sized integral brake.

Also, where possible, use the smallest motor for the application so that it is loaded near 80% and operates as close to it nameplate efficiency as possible.

5. Mechanical efficiencies matter, too.

Worm gear units, which are very common in the industry, have an efficiency range of 50 to 88 percent, depending on the number of starts (teeth) on the worm gear, as shown below.

number of starts	typical efficiency range
1	50-69%
2	70-79%
5	80-88%

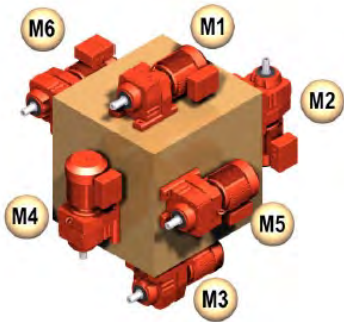
Their poor efficiency is due to sliding gear contact. Since sliding produces friction, much of the energy is wasted through heat. Conversely, helical bevel gear units use rolling friction, so they lose only 1.5% of efficiency for each stage. Thus, a 3-stage helical bevel gearbox is 95.5% efficient.

Although helical-bevel gear units are higher in initial cost, they will save money in energy over the lifetime of the system. If you are an end-user, consider specifying helical-bevel gear units the next time you purchase equipment for your plant. It is in your best interest.

6. Gearmotors eliminate even more efficiency losses.

Gearmotors inherently yield tremendous increases in efficiency compared to the average flexible transmission system. Since a gearmotor contains a motor that is rigidly coupled and precisely aligned with the gear unit, the connection is nearly 100% efficient. By eliminating the friction and slippage associated with V-belts, pulleys or chains, you can quickly gain 12-15% increase in efficiency. Plus, you'll save even more on the replacement and maintenance of belts. And, don't forget about safety...

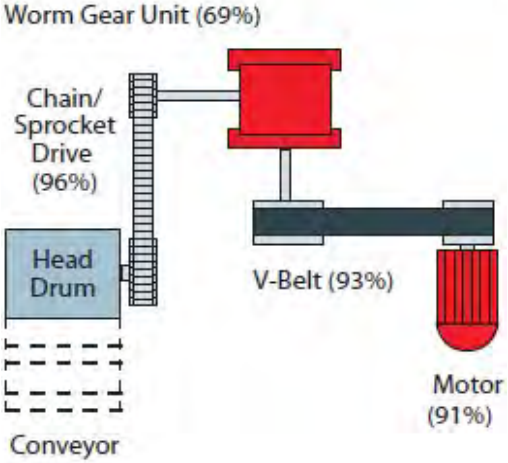
7. Oil may be costing you.



Oil plays an role in energy savings because it creates heat as it churns inside a gear unit. And, the amount of heat increases as the oil volume increases. Not only does heat increase your energy bill, it also damages gears and seals. Excessive heat is especially problematic for larger gear units - typically with an output shaft diameter greater than 2.25".

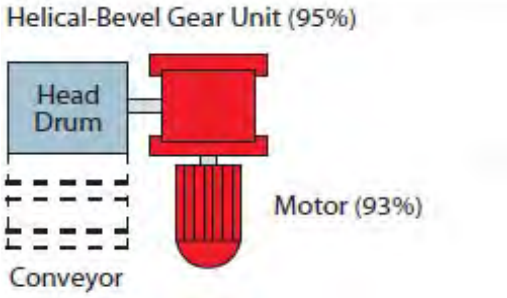
Standard vs. Optimized

Standard:



Overall drive train efficiency = 56.1%
Power required from utility = 16.2kW
Energy used = 64.8MWh per year
Cost of energy = $6,480 per year
Power loss from inefficiency = **7.1kW**

Optimized:



Overall drive train efficiency = 88.3%
Power required from utility = 10.3kW
Energy used = 41.2MWh per year
Cost of energy = $4,120 per year
Power loss from inefficiency = **1.2kW**

Comparison Summary:

- **57% efficiency increase**
- **23.6MWh energy savings/yr.**
- **$2,360 savings/yr.**

[1]Given conditions: 20 HP motor operated 16 hrs/day, 250 days/year • Application requires that 9.1kW be delivered to conveyor head drum • Cost of energy = $0.10/kWh • Motor in standard example is high efficiency per EPAct 1997. • Motor in optimized example is premium efficiency per EISA 2007.

Consider the following when designing or servicing your gear units:

- **Mounting Position:** The orientation of the gear unit determines the amount of oil. M1 contains the least; M2 and M4 contain the most. Whenever possible, design your system for M1.
- **Input Speed:** The faster the oil churns, the higher are the churning losses. Therefore, a gear unit with a 4-pole motor (1800 rpm) will run cooler than with a 2-pole motor (3600 rpm).
- **Synthetic Oil:** Synthetic oil is known to reduce friction by 25%, which can be significant on worm units or large gear units. Not only does synthetic oil allow the gear unit to run cooler, it also doubles the oil service life, which reduces your maintenance interval and costs.
- **Viscosity:** The "thicker" the oil, the more resistance it has to flow and the more energy it requires to move. Always use the correct viscosity, considering the type of application and ambient temperature.

Conclusion

As you can see, energy-efficient motors play an important role in reducing energy usage and increasing cost savings. But they are by no means the cure-all to every energy consumption problem. In addition to weighing the characteristics of the energy-efficient motors available on the market, it's important to consider all of the elements in the drivetrain equation.

For maximum energy savings:

- Replace the motor with a NEMA Premium motor, such as the SEW DRP.
- Choose a motor appropriate to your particular application.
- Replace worm gear units with helical-bevel gearboxes.
- Use the most efficient drivetrain,

such as a gearmotor configuration.

- Eliminate flexible transmission elements.
- Use a VFD to optimize your motor efficiency, control its energy usage, or recover regenerative energy - providing your application merits its use.
- Consider if your efficiency gains will allow you to use a smaller motor for your desired application.

For more information about SEW-EURODRIVE's new DR motor series of energy-efficient motors, click here or contact Sales for your local SEW representative.

For more information about SEW-EURODRIVE and its complete line of energy-saving motors, drive controllers, and gearboxes, visit www.seweurodrive.com.

Now, you can create your own custom gearmotor quotation, including all options and CAD drawing fast and easy with SEW's exclusive PT Pilot program.

Visit www.ptpilot.com.