Saving Money with High-Efficiency Gearmotors

Joseph L. Hazelton, Contributing Editor

Standing in a factory or a warehouse, you're bound to notice machinery, whether it's a conveyor system that winds across the floor or large fans that hang from the ceiling. You may even notice automated guided vehicles or autonomous mobile robots carrying parts, driving themselves from one section of the building to another.

These machines — conveyors, fans, AGVs, AMRs — are good candidates for using high-efficiency gearmotors, especially if they're expected to run for long stretches at a time. If they aren't using high-efficiency gearmotors, then they may be costing more money than they should.

Machines' gearmotors can have a sizable effect on an energy bill. According to Christopher Moskaites, depending on the facility, its gearmotors may account for up to 50 percent of its energy bill.

Moskaites is product manager — electro-mechanical solutions for Lenze Americas. Located in Uxbridge, MA, Lenze makes gearmotors for the logistics and automation industries, among others.

Given their effect on energy bills, the long-running machines get the most attention from companies that want to save money. "They really focus on the ones that are more continuous duty," Moskaites says.

To save money with high-efficiency gearmotors, an end user has to consider many things, big and small, from whether its application runs long enough to benefit from high-efficiency gearmotors to how many gear stages are needed in a gearmotor's gearbox.

Long Stretches of Time

High-efficiency gearmotors reduce energy costs when the gearmotors are used in machines that operate continuously or near continuously.

Now, it's easy to figure out which machines operate continuously. They operate 24/7/365.

But, which machines operate near continuously? What does "near continuously" mean? That is, how many hours does a machine have to run for it to operate "near continuously"? Does it have to run 20 hours? Fifteen hours? How many hours are enough?

Several, according to Michael DeMeo.

He's national electronics sales engineer for SEW-Eurodrive Inc. Located in Lyman, SC, SEW-Eurodrive makes gearmotors for a number of industries, including the airport and parcel industries.

DeMeo says that after a system is up and running continuously for several hours, energy savings can be obtained, especially if the system is operating at peak load. He adds that in a 24/7 operation, a system may operate continuously for only five to six hours during each eight-hour shift and still show energy savings.

Depending on the application and its load, though, several hours may not be enough, but to operate "near continuously," a machine doesn't have to be running for 18, 19, 20 hours.

Now, AGVs and AMRs, because they use batteries, they need high-efficiency gearmotors in order to run as long as possible,

"If you're running on a battery and you're not efficient, your battery is not going to last very long, and you're not going to get a lot of work done in the warehouse," says Matthew Roberson.

Roberson is vice president of Brother Gearmotor, a division of Brother International Corp. Located in Bridgewater, NJ, Brother Gearmotor serves the food and beverage industry, the packaging industry, and others.

Naturally, AGVs and AMRs need to recharge their batteries from time to time. But, the more efficient their gearmotors, the less often they need to — and the more work they get done between recharges.

Gauging Efficiency

But, how to know whether the gearmotors in an application are high efficiency? And if they aren't, how to know whether high-efficiency gearmotors would reduce energy bills?

One way to find out both things: Bring in a gearmotor manufacturer.

A number of them are willing to look at the gearmotors in an application, measure the energy consumption of the application, decide whether high-efficiency gearmotors could be installed, and estimate how much less energy would be consumed if they were installed.

Now, gearmotor manufacturers will measure an application's energy consumption rather than its energy efficiency because efficiency can be tricky to calculate. Also, by looking at energy consumption, they avoid the possibility of *system* efficiency being mistaken for *gearmotor* efficiency.

Both practices are explained by Tom Koren, director of engineering for Nord Gear Corp., Waunakee, WI. Nord makes gearmotors for a number of industries, including the airport and steel industries.

What makes efficiency tricky to calculate is: A gearmotor may be operating normally, no problems, but what about the rest of the application, say a conveyor system? What if there's a problem elsewhere in the system, a problem that makes the gearmotor seem less efficient?

"Was there a worn bearing binding up on the conveyor during our test?" Koren says. "We don't know."

Because there's always the possibility of a problem elsewhere, a gearmotor manufacturer may decide it best not to suggest that a competitor's gearmotor is less efficient when it may only *appear* to be less efficient.

As for why measure energy consumption: "You don't tie dollars signs to efficiency," Koren says. "Efficiency is really what you're improving, but it's not what you're paying for. You're paying for energy."

So, gearmotor manufacturers would report on the number of kilowatt-hours consumed by a system, not on the percentage of a gearmotor's energy efficiency.

Measuring Energy Consumption

Now, a system's energy consumption can be measured in several ways: theoretically, actually, and with a one-off replacement.

For example, a theoretical study would include a detailed list of a system's conveyors, their expected loads, and their expected energy consumption. In an actual study, the system would be equipped with devices for recording the actual energy consumption.

A one-off replacement study would involve replacing one gearmotor in a system. In this case, to start off, a gearmotor would be selected and a power meter attached to it to record energy consumption. The gearmotor may be a system's worst-case scenario, the gearmotor that uses the most energy because, for example, it powers a conveyor with an incline.

After some time, the power meter would be detached, the gearmotor removed, a new gearmotor installed, the meter reattached, and energy consumption recorded again. In the end, energy consumption with the old gearmotor would be compared to energy consumption with the new one.

However, both actual study and one-off replacement may take considerable time, depending on the application.

To illustrate, Koren estimates the time for an actual study of a conveyor system at an airport: three months. "We like to get two to four weeks of data per conveyor type or conveyor setup," he says. "There's inclines, there's declines, there's merges, there's transfer conveyors." After the data is gathered, the rest of the time is spent analyzing it and creating a proposal for new gearmotors. Naturally, if the conveyor system is more complicated, the study would likely require more time.

Besides being complex, though, a system would take time to study if it handles variable loads. The airport conveyor system is a good example. "You can't go in for a couple days because you need to look at the average bag traffic," Koren says. "The weekend travel is much different than the weekday travel. And a month with holidays, as in the Fourth of July, there's less business travelers."

Koren adds, though, that a system with a consistent load would likely require fewer days for gathering data: "You can go in and snap a smaller picture."

Like an actual study, a one-off replacement study could take months. According to DeMeo, a power meter could be left on a gearmotor for four weeks.

To Save Money Takes Planning

Now, with a study taking months, it can be easy to lose sight of the real goal: saving money with high-efficiency gearmotors.

If the goal is kept in sight, though, then knowing how long a study takes, can be a help. An end user can plan for a lengthy study. It can estimate total time for the whole process: time for the study, time to review and decide on the proposal, time to install the new, high-efficiency gearmotors.

Knowing the total time is especially important if the money for improving a system is available for a limited time, like until year-end. That way, an end user can contact gearmotor manufacturers long, long before year-end, avoiding a time crunch.

Some end users, though, may not need a study to be sure of lowering their energy bills. "There is real cost savings," Koren says, "and some people realize that and just spend the money upfront, but majority wants the studies."

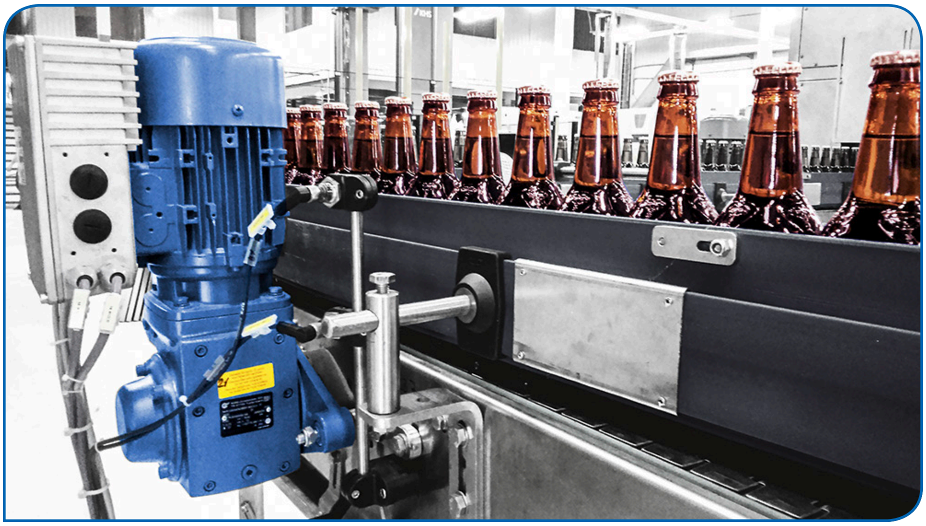
Starting with the Motor

Now, doing a study may be complicated and time consuming, but finding a high-efficiency gearmotor starts simply with the motor, with one that generates enough starting torque and continuous torque for an application, whether a small AGV or a large conveyor system.

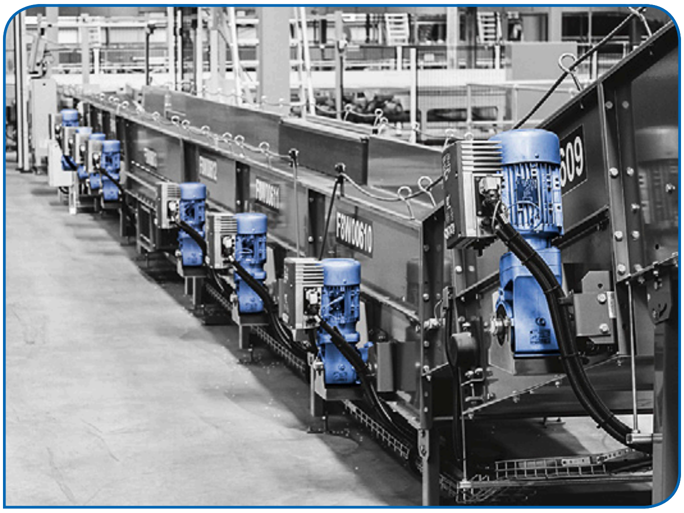
The needed torques may be found in different types of motors, from a standard AC induction motor to a permanent magnet motor (PMM). If a motor type isn't efficient enough, it may be possible to modify it so it can be energy efficient. For example, AC induction motors can be made with more copper windings.

However, depending on the application, it may be necessary to change to a different motor type in order to have high-efficiency gearmotors.

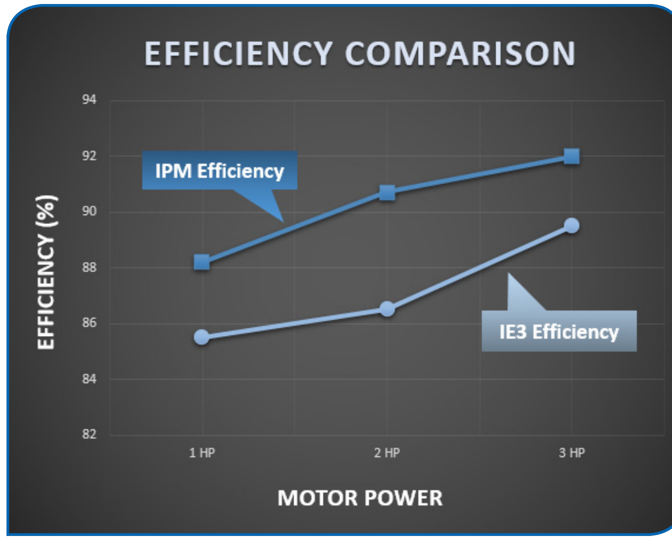
For example, a different type may be needed if the application handles variable loads. In that case, the system's motors



An application's load and speed, whether they're constant or variable, are considerations when trying to lower energy costs through high-efficiency gearmotors. (Photo courtesy of Nord Gear Corp.)



The larger an application, the more gearmotors it has, and the more its energy bills may be reduced through high-efficiency gearmotors. (Photo courtesy of Nord Gear Corp.)



A gearmotor's high efficiency depends in part on the motor's efficiency. An application's best efficiency may be obtained in part through a particular type of motor, like a motor with an internal permanent magnet. (Photo courtesy of Brother Gearmotor)

may be slowed down when it's handling a lighter load.

However, high efficiency at full load may not be high efficiency at partial load. Koren explains: "You might have a 90 percent efficient motor, but at half load, it might only be 70 percent efficient."

Koren adds an example of where high-efficiency gearmotors could be running inefficiently at partial load: a distribution warehouse in the retail industry. In that case, the warehouse would've sized its conveyor system to handle a peak load that occurs during part of a year, like the holiday season. But, what about the rest of the year?

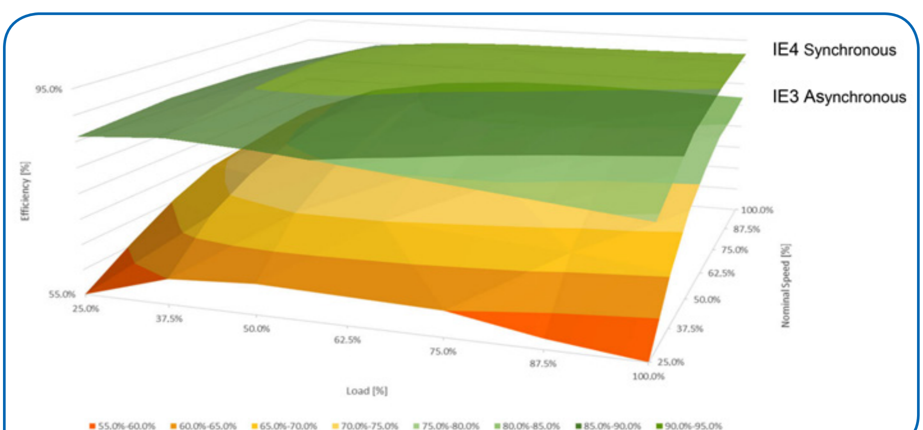
"In July, that conveyor might be at 25 percent load," Koren says. "With standard motor technologies, that is a very inefficient system. With permanent magnet motor technologies, it's a very efficient system."

Koren explains that the difference is the PMM's efficiency curve: "It's a very flat efficiency curve." So, a highly efficient motor at 100 percent load would still be highly efficient at 50 percent load. "A permanent magnet motor does not lose that efficiency at partial load or partial speed," Koren says.

PMMs are more expensive, but the extra expense may be offset by extra savings from a system that's highly efficient whether its load is heavy or light.

To figure the savings, an end user would need to look at total cost of ownership with its current gearmotors and estimated total cost of ownership with PMMs. Then, it could see when the extra savings would equal the extra expense, could see the breakeven point. After that point, the extra savings that were paying for the more expensive motors, could become extra savings spent elsewhere or banked.

To take advantage of its efficiency curve, a PMM would need to have a motor controller, also called an inverter. In applications with variable loads, the controllers could also increase the energy efficiency of the motors by allowing them to index and turn themselves on and off.



If an application, such as a conveyor system, handles variable loads and speeds, permanent magnet motors may be the option for high-efficiency gearmotors. PMMs may be the option because of their relatively flat efficiency curve at partial load and partial speed. (Photo courtesy of Nord Gear Corp.)

If an application's load and speed are variable, then its gearmotors may need to be topped with motor controllers so the gearmotors, and the application, are as energy efficient as possible. (Photo courtesy of SEW-Eurodrive Inc.)

"Does the conveyor need to run constantly, waiting for a box or a suitcase?" Koren says. "Or can it wait for a suitcase to be fed to it and then turn on and turn back off?"

This efficiency could be lost, though, if a motor is indexing excessively. "If you're indexing too often, it does take extra energy to accelerate and a waste of energy to decelerate," Koren says. "It might make more sense to just leave it running."

Excessive indexing—that is, reduced energy efficiency—can be avoided through a programmable logic controller. A PLC can operate its motor in the most energy-efficient way. For example, once a system's most efficient indexing rate is figured, the PLC can be programmed to include the minimum load for continuous running. Koren describes the communication between the motor controller and the motor: "If my demand gets below this, then slow down the speed or turn off altogether."

Rightsizing the Motor

While figuring out a system's motors, an end user faces another challenge: not oversizing.

According to Moskaites, historically, end users have tended not to use properly sized motors; they've tended to oversize, which wastes a lot of energy. "We find that a lot," he says. "That's a good way to conserve energy, is just to make sure you're using the proper motor."

An oversized motor may be part of a system because somebody chose the motor years ago and since then, whenever it needed to be replaced, no one thought to try another size. Moskaites knows that situation: "Somebody just says, 'I've always used a five-horsepower motor, I'll just keep using that.'"

Another reason for an oversized motor: An end user wants safety, perhaps too much safety. If too much: "that safety that you're building into the system, may cost you thousands of dollars a year," Koren says.

Today, however, end users appear to be rightsizing their motors more often than they used to. That's what Moskaites has observed. When he walks through facilities, he does see oversized motors in many conveyor systems, but he adds: "It's starting to happen less and less."

Or, an end user may oversize because it doesn't want to run a fan to cool the motor. A system may need only one-quarter horsepower to operate, but the end user buys a five-horsepower gearmotor so it won't overheat. The end user saves energy by not running a fan, but it now has a five-horsepower gearmotor doing one-quarter horsepower of work.

"You lose your efficiency," DeMeo says.

One more reason that a motor may be oversized: An end user may not know how much power is actually needed by its system.

To figure out the needed power, DeMeo uses a conveyor system as an example. Begin with the system's starting torque, but assume the system will sometimes need to be started when it's fully loaded, when the starting torque will need to be greatest.

Say the starting torque needs to be 200-plus percent, so a two-horsepower motor with a five-horsepower frequency inverter is installed. The conveyor system now has its needed starting torque.

However, once the system is started, it may need only one horsepower to keep running. "So, I'm wasting all this money," DeMeo says, "all this sizing, all these bigger sizes, just to get by with that starting torque."

Moreover, he points out: "I still need a certain amount of energy to keep that two-horsepower motor energized even though I only require one horsepower."

The starting torque of four-plus horsepower, though, can be had through a one-horsepower permanent magnet motor.

"For the same one horsepower, you gain the starting torque without increasing the size of the motor," DeMeo says. "So, after we get our two, three hundred percent starting torque, then I'm still just a one-horsepower unit, and I'm not wasting any energy trying to keep my two-horsepower motor energized."

"That's basically the gain of a permanent magnet motor," he adds. "That leads to the efficiency."

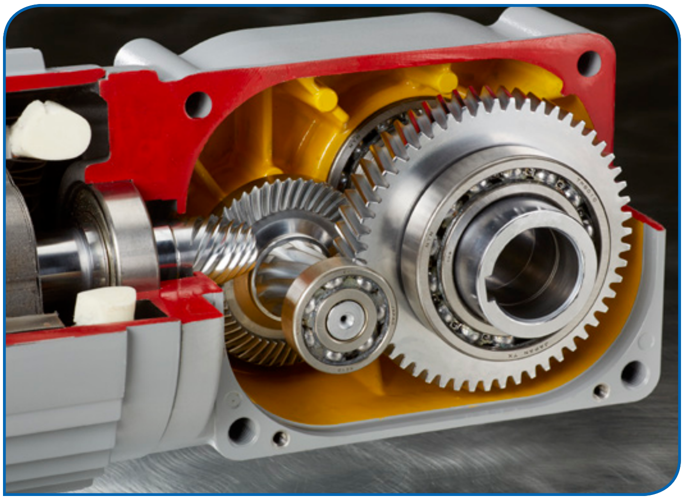
The Gears: Type, Ratio, and Stages

"A lot of people focus on the motors. And that's good; you should," Roberson says. However, he adds: "Sometimes, it doesn't make sense to put a high-efficiency motor on a less-efficient gear train."

The efficiency of the gears depends on the type of gears. There may be times when gear type is limited by the application. When it isn't limited, though, the most efficient gears should be selected. As examples, bevel gears and helical gears are more efficient than worm gears.

A gear set's efficiency also depends on its gear ratio. The higher the ratio, the more efficient the set. The ratio indicates efficiency because it indicates how quickly the gears are changing the speed of the motor's power. The faster the change, the more efficient the gear set.

Also, higher gear ratios can contribute to a gearbox's efficiency by minimizing the number of gear stages. Each stage consists of additional components that receive the motor's power, transmit it, and subtract from it. So, the fewer stages, the fewer components, the fewer subtractions, the more



In a gearmotor, the gear set may consist of more than two gears, more than a driving gear and a driven gear. If the number of gears is minimized, the gearmotor's energy efficiency may be best kept at a high level because less energy is lost as friction between the gears. (Photo courtesy of Brother Gearmotor)

efficient the gearbox. "You have less shafts, less bearings, less seals, less gears in contact, less churning losses in the gearbox," Koren says.

Integrating Gearbox and Motor

Depending on the application, the number of components may also be reduced by integrating the gearbox and motor. The resulting gearmotor may be preferable because: "When you make a compact, integral system — gearbox, motor, all in one package — you eliminate certain components, increasing the overall energy efficiency," Koren says.

To illustrate, he mentions an older conveyor system in which the motors were connected by clutches to their gearboxes. The system's owner, an airline, was thinking about replacing the drives, more than 800, with new ones in an effort to use less energy, to save money.

After the system's energy consumption was studied, the motors, clutches, and gearboxes were replaced with gearmotors and motor controllers. Instead of clutches being engaged and disengaged, motors were turned on and off. The system's energy consumption was studied again.

The result: "It was significant energy savings," Koren says.

Outside the Gearmotor

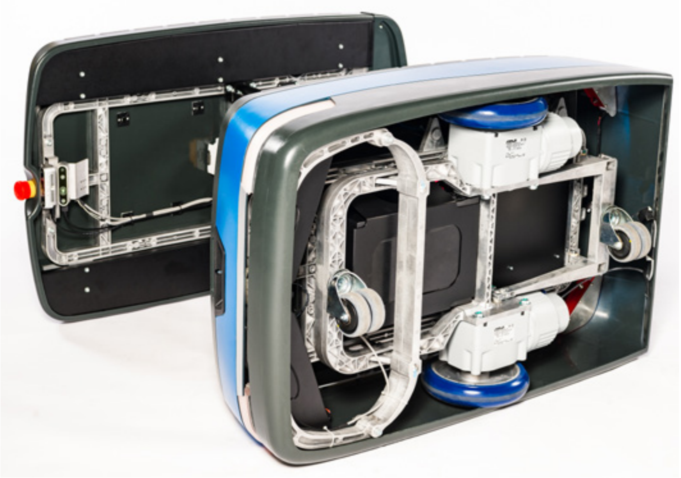
Getting rid of components may be possible outside the gearmotor, too.

Roberson explains that AGV and AMR manufacturers generally prefer their gearmotors be right-angle gearmotors. That way, each gearmotor can be connected to its wheel assembly by a hollow shaft alone, no other components.

"What we're finding in the AGVs and AMRs is they're taking their wheel assembly and they're plugging it in — basically — to the gearmotor," Roberson says.

If it weren't a right-angle gearmotor, if it had a different configuration, the connection might require additional components, like a belt or a chain. "Which is really just another system of energy loss," Roberson says.

He adds that a right-angle gearmotor is a standard request from AGV and AMR manufacturers. "You can see that trend out there," he says. "That compact design, ability to have a plug-in wheel, and not other components within the drivetrain that would lose energy."



Depending on the application, a gearmotor's mounting configuration may keep energy losses to a minimum by keeping to a minimum the number of components between the gearmotor and its energy's final destination, such as the blue wheels on an AGV. (Photo courtesy of Brother Gearmotor)

Consequently, when it comes to saving money by using high-efficiency gearmotors, it's like Koren says: "It's more than just the energy efficiency of motors. It's proper sizing and selection of all the mechanical components." **PTE**

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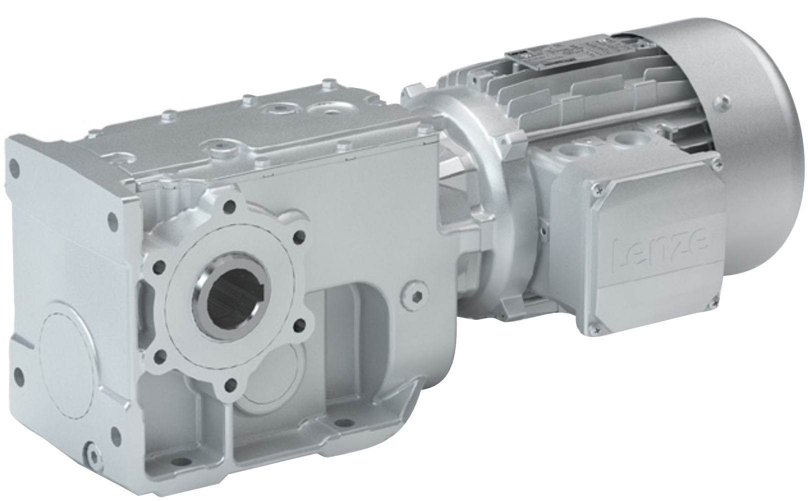

A gearmotor's efficiency may be best kept at a high level when its energy passes through as few components as possible. Depending on the application, components may be kept to a minimum in part through the gearbox's configuration, such as inline or right angle. (Photo courtesy of Lenze Americas)