Written by Karen Lee Nafzinger, Philadelphia Mixing Solutions
Thursday, 01 January 2009 00:00

As statistics go, these certainly grab your attention. Energy consumption is expected to increase by 20% over the next 15 years, and its cost and availability will have a substantial impact on the economic health of U.S. manufacturers and municipalities. The industrial sector accounts for approximately one-third of the energy consumed annually in the United States—an estimated $116 billion. On the public side, the U.S. Department of Energy estimates that processing municipal drinking water and wastewater consumes more than $4 billion in taxpayer dollars per year[1]. Public utilities—which account for up to 35% of all municipal energy consumption—can put a real dent in state energy budgets.

In addition to skyrocketing energy costs, manufacturers and municipalities face increasingly stringent energy and environmental regulations. Recent legislation has expanded the commitment of the Energy Policy Act of 2005 (EPAct), calling for 25% reduction in energy use by 2017. The Energy Independence and Security Act President Bush signed in 2007 mandates motor efficiencies beyond the minimums of the 1992 Energy Policy Act. This bill goes into full effect in December 2010.

What does this mean for water and wastewater treatment (WWT) plants? By more efficiently using their energy resources, these operations could lower production costs while increasing productivity—with the potential for capturing millions of dollars in bottom-line savings. They also could decrease emissions of pollutants such as sulfur oxides, nitrogen oxides, particulates and other greenhouse gases.[2] This would help publicly owned treatment works (POTW) get ahead of the stricter regulations now looming on the horizon. For example, the Wisconsin Water Association[3] estimates that saving 100 horsepower in a water treatment facility can:

- Save 657,000 kWh per year, enough to power 65-70 homes
- Avoid 290 tons of carbon dioxide
- Avoid 1971 pounds of sulfur dioxide

- Avoid 986 pounds of nitrogen oxide

So, there is a proven corollary between energy efficiency and environmental output. When applied nationwide, these numbers become significant. In 2005, an estimated 25.4 and 8.0 Tg CO_2-equivalent of CH_4 and N_2O, respectively, resulted from organic sludge degradation in wastewater treatment systems—more than 0.5% of America's total greenhouse gas emissions.[4]

This is where capital equipment counts. Along with pumps, mixer drives are major energy consumers that directly affect throughput. While mixers represent significant capital investments, they are one of today's most overlooked and misunderstood energy users. Accordingly, enhancing mixer performance reduces energy consumption, improves process flow, improves pump performance and directly impacts the bottom line at WWT facilities.

Yes, we know…but

Although plant operators are aware of the benefits of increased energy efficiency, they often resist implementing the changes necessary to achieve these goals because of the challenges involved. Increasing efficiency for substantial, measurable results requires both proper motivation and an engineer's insight into the root causes of inefficiencies — which most commonly reside within the plant's mixers and other capital equipment.

In spite of costlier production and new legislation, the country's 15,000 municipal wastewater plants have little immediate incentive to improve energy use. This group measures success by basic compliance. Most POTW do not control their own budgets and ultimately have no responsibility for the bottom line. Regulatory compliance and continuous operation are the areas for which they are most accountable.

A second challenge to energy efficiency involves the identification of all of the root causes behind "phantom" inefficiencies. This is a complex task that applies to all operators, regardless of industry niche. Ferreting out the origins of inefficiencies provides measurable returns to the bottom line, and usually improves throughput and reduces by-products. For these reasons, improving the energy efficiency of wastewater processing is important to every operator.

That will be $1 trillion, please

Energy use—kilowatts and dollars—in wastewater processing varies widely, depending on an array of variables that include:

- Regional energy costs
- Type of wastewater being treated
- Type of process used
- Type and age of equipment
- Regulations governing output quality

According to the Consortium for Energy Efficiency (www.cee1.org), POTW use 2% to 35% of their operating budgets on energy, and more than 50% of that total energy use is in aeration treatment.[5] If nothing changes, these numbers are likely to increase considerably as America's municipal infrastructure continues to age. (Most POTW are 30- to 50-years old, meaning they were designed and built when energy efficiency was not a national concern. [6]) Things, however, are changing. Experts predict that as new health regulations and population growth further stress public water systems, nearly $1 trillion in investments will be needed over the next 20 years to meet current environmental mandates.

Industrial wastewater processing also is subject to tightening environmental regulations. Commercial manufacturers, though, have enormous motivation to improve energy efficiency as it directly impacts the bottom line. This takes on an even larger role at a time when raw material and transportation costs are skyrocketing and the world struggles with an economic recession.

Interestingly, in the industrial sector, the proportion of investments in energy efficiency (25%) is lower than the proportion of energy use (34%). According to one report, even when they were under-achieving, industrial manufacturers saved $5.6 billion by improving energy efficiency.[7]

That means there is still a long way for industrial operations to go—but good reason for going there.

The industrial sector, however, invests in energy efficiency differently than other wastewater operations. Retrofit opportunities are limited, project cycles can be substantially longer and efficiency upgrades are generally undertaken only when they can be coordinated with overall capital expenditures for facility upgrades. Investment is further slowed because ROI can take three to five years, depending on the industry and the nature of the improvements.[8]

In the United States, 80% of all the energy used in manufacturing is consumed in the following industries*, listed in order of kWh used:

- Coal, metal ore and nonmetallic mineral mining
- Food and beverage
- Textiles
- Wood products and paper
- Petroleum refining
- Chemicals
- Plastics and rubber products
- Glass and glass products
- Cement
- Iron and steel mills
- Alumina and aluminum
- Foundries
- Fabricated metals
- Heavy machinery
- Computers, electronics, appliances, electrical equipment
- Transportation equipment

**All other manufacturing industries account for the remaining 20% of energy used.*

Mixer performance and opportunities

Mixers play a major role in virtually every wastewater process, including aeration, flocculation,

froth flotation, activated sludge and trickling filters. They also are used in primary, secondary and tertiary sewage treatment. Mixer inefficiency can originate in any number of areas, from inaccurate pre-purchase specification to changes in the process requirements to improper repair to simply running the mixer in the wrong direction.

Improper equipment specification…

Although wastewater plant design is a sophisticated feat of engineering, equipment frequently is specified improperly in the final plan. Engineers, consultants, operators—in other words, every vested party—seem to want to "leave room for error." This often yields a plant with equipment that exceeds needs by 25% or more before it is even commissioned. Conversely, budget constraints can cause specifiers to choose underpowered mixers. In this case, the equipment operates at more than 100% of spec from day one.

Both mistakes kill energy efficiency.While energy usage is based on horsepower, mixer performance is best measured by torque, and should be selected via load modeling based on this criteria.

Universal application/change in application…

In an effort to conserve money, operators often specify one model of mixer for all of the wastewater applications in their facility. These bulk-purchase savings turn into huge deficits as soon as the electric meter starts running. To maximize efficiency, operators should evaluate every individual application and select equipment based on:

- Vessel size and shape
- Depth or volume of liquid
- Velocity gradient
- Specific gravity
- Viscosity
- Mixing intensity

In a related situation, operators sometimes change applications without updating their mixing equipment. Wastewater streams may be moved or altered for any number of reasons, including:

- Change in scale/scope of production (scale down/scale up)
- Elimination of products from product line
- Change in regulations
- Change in upstream processes
- Change in raw materials or production process
- Change in basin size or configuration

Any of these changes can drastically impact a mixer's load and energy efficiency. It is unrealistic to assume that a mixer will continue to provide peak performance in an environment that is different from the one for which it was specified. Thus, any of these changes require a re-evaluation of the entire system, including pipe diameters, pipe networks, ducts and flow control devices such as valves, regulators and dampers.

Mixers use drives designed for the loads being applied to them. If the load exceeds the specification it will reduce the mixer's efficiency—this often occurs when operators increase process volume in an attempt to maximize throughput. Some operators try to circumvent the problem by over-specifying the gear drive. But this isn't energy efficient, either. A larger than-needed drive develops additional friction, which needlessly increases energy consumption.

In other cases, operators try to increase throughput by changing an impeller to a larger size or remove tank baffles. Retrofitting the wetted parts without consulting a mixing expert not only threatens energy efficiency, it also can reduce mixing efficiency. What's more, it can damage the mixer drive by creating loads beyond the equipment's capacity. This will lead to mixer breakdown and unplanned— and costly—downtime.

A comprehensive process change, though, can enhance energy consumption. Some POTW, for example, could reduce sludge recirculation during low influent conditions, thus reducing energy demand. Denitrification of lower nitrate loads in the anoxic zone typically remains stable during low influent periods since less oxygen is produced from the denitrification process.

Installation, service and upkeep…

Improper mixer installation can rob even a well-designed system of its designed efficiency. Planners, working with a mixing expert, must consider mixer placement and impeller technology when building or upgrading. A side-entry mixer, for example, may provide better mixing using a smaller drive motor (less energy consumption) than a top-mount mixer, depending on basin size, configuration and process materials. Just because an operator used a top-mounted mixer in the past doesn't mean it's still the best solution; many mixing technologies are available today that didn't exist when plants were originally built.

Assuming that the set-up is correctly executed, staying on scheduled maintenance timetables is one of the easiest and most cost-effective ways to maintain peak performance. Stretching or missing scheduled maintenance causes excessive wear—which contributes to suboptimal energy usage.

Working toward efficiency

Research by the Industrial Electric Motor Systems Efficiency Workshop for the G8 Plan of Action indicates that up to 7% of global electricity demand could be saved by optimizing motor-driven equipment in industrial processes.[9] Energy consumption accounts for approximately 97% of the cost for motor-driven equipment over its lifetime.

Wastewater handlers employ multiple mixers and aerafltors in their processes, and thus have several opportunities to up their throughput while improving energy efficiency. They can accomplish this by being mindful of the guidelines contained in this article and consulting with a mixing expert for specific action items. **UM**

Karen Lee Nafzinger is vice president of Philadelphia Mixing Solutions, a leader in equipment and process optimization for chemical processing, wastewater biological treatment, industrial wastewater treatment, tank storage, special application mixing, flue-gas desulfurization (FGD), water treatment and other fluid-mixing applications. The company offers a complete range of gearboxes, mixer drives, shafts, aerators and specially designed impellers to measurably reduce energy and maintenance costs while improving operational efficiency. Its custom-built, state-of-the-art test lab facility simulates full-scale operations and offers quick-turnaround testing and modeling of alternative mixing designs. All of Philadelphia Mixing Solutions test and manufacturing facilities are certified NQA-1 Standards and ISO 9001:2000. For more information, telephone: (800) 956-4937.

Additional Resources

There are numerous resources available to operators. Don't hesistate to check them out, including the following:

- American Council For An Energy Efficient Economy
- EPA
- American Society of Civil Engineers

References

1. Energy Star program fact sheet, U.S. Dept. of Energy, 2008
2. "Energy Use, Loss and Opportunities Analysis: U.S. Manufacturing and Mining," December 2004, prepared by Energetics Inc. and E3M Inc. for the U.S. Department of Energy, Energy Efficiency and Renewable Energy Industrial Technologies Program
3. "Focus on Energy," Joseph Cantwell, P.E., SAIC, Wisconsin Water Association, April 17, 2008
4. "Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2005," U.S. EPA, 2007
5. "Energy-Saving Opportunities at Water/Wastewater Plants," Lory E. Larson, Southern California Edison Co., May 15, 2002
6. Ibid
7. "The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture," Karen Ehrhardt-Martinez and John A. "Skip" Laitner, American Council for an Energy-Efficient Economy (ACEEE), May 2008
8. "Trends in Industrial Investment Decision Making," R. Neal Elliott, Ph. D., P.E., Anna Monis Shipley, and Vanessa McKinney, ACEEE Report #IE081, September 2008
9. "Industrial motor systems energy efficiency: Towards a plan of action," Industrial Electric Motor Systems Efficiency Workshop, May 15-16, 2006