ELECTRIC POWER RESEARCH INSTITUTE

Quick Insights

Productivity Improvements and Benefits of Efficient Electrification

RESEARCH QUESTION

Can efficient electrification improve the productivity of commercial and industrial facilities?

KEY POINTS

- Efficient electrification has the opportunity to boost energy efficiency and grid flexibility, increase productivity, and improve product quality while supporting emissions reduction, water savings, and safety throughout society.
- There are several examples of electric technologies in commercial and industrial facilities that offer significant productivity gains. While not comprehensive, this brief highlights some of these opportunities.
- Ongoing research at the Electric Power Research Institute (EPRI) continues to assess the potential benefits and opportunities of existing and emerging efficient electric technologies.

INTRODUCTION

Efficient electrification—the application of energy efficient electric technologies as alternatives to fossil-fueled processes—is a central pillar of EPRI's pathway to an Integrated Energy Network. Economic and environmental factors are expected to increasingly reward and drive the application of a number of electric technologies to boost energy efficiency and grid flexibility, increase productivity, and improve product quality while supporting emissions reduction, water savings, and safety. Recent Quick Insight briefs discussed potential water saving opportunities as well as potential health and safety benefits associated with efficient electric technologies. This brief highlights some of the technologies that can offer improved productivity gains to commercial and industrial facilities. Productivity could mean different things to different industries. Some common examples of productivity gains could be producing more widgets per hour than the incumbent technology, increasing production line speed, reducing downtime in a process (e.g., maintenance shut down), or reducing product waste/scrap.

PRODUCTIVITY IMPROVEMENTS WITH EFFICIENT ELECTRIFICATION

The use of efficient electric technologies in commercial and industrial facilities has resulted in several benefits to the facilities that have adopted them. One of the key potential benefits is improvements in plant productivity. While by no means an exhaustive list, the following examples demonstrate the potential productivity benefits from efficient electric technologies.

Electric Forklifts

Material handling vehicles are used in virtually every industry to transfer cargo, stock, and pallets, and forklifts (also known as lift trucks or fork trucks) are one of the most widely used material-handling vehicles. They can be found in a variety of logistical operations, such as distribution warehouses and shipping depots, and are primarily used for lifting and moving heavy loads within and around facilities. In the last six years, market acceptance of electric forklifts has steadily increased. Advances in motor drive, battery, and charger technology have dramatically improved equipment performance and utility, and therefore industry acceptance—even in demanding multi-shift operations. Roughly 64% of the total North American forklift market and more than 70% of the European Union forklift market are now electric. For many applications, electric forklifts offer equal or superior performance and significant cost savings.[1]

One example is Southern California-headquartered building material manufacturer CEMCO's switch to electric forklifts. In 2011 and 2012, CEMCO plant in Pittsburg, California, replaced eight of its ten Class 5 liquefied petroleum gas (LPG), or propane, forklifts with Class 1 electric models due to the savings from switching to electric fuel and in consideration of the air quality regulation compliance benefits. The plant operates up to two 8-hour shifts, five days a week and forklifts run continuously throughout each shift both indoors and outdoors. Six 6,000-pound electric forklifts operate in the shipping department, where they lift finished pallets of products onto trucks headed for customers and pull incoming raw materials off delivery trucks, and two 10,000-pound electric forklifts work in the production department, moving steel coils to the machines that form the finished products and pulling the finished products into a staging area.

While CEMCO's primary consideration for switching from LPG to electric forklifts was economic, there were other benefits they discovered in the process of converting to electric, which included productivity gains and reduced emissions. Prior to conversion, fuel costs per day were in the range of $64-$96* while the fuel cost for an electric forklift for the same operation was approximately $21 per day.† Maintenance costs were also reduced and waste disposal costs of oil and filters were eliminated. An added benefit of switching to electric was that the plant had an increase in productivity due to the reduced downtime for maintenance and oil changes. In addition, the operators no longer lost time switching out propane tanks, which would take approximately five minutes, or filling a tank, which could take even longer at 15 to 20 minutes. Now, employees simply drive the lift truck to the charger and plug it in at the end of the second shift since the electric batteries are large enough to support the two full shifts of operation.

Using EPRI's forklift comparison calculator to analyze the ownership cost of 6,000-pound electric, propane, and diesel forklifts shows that electric forklifts offer savings over those powered by propane and diesel. In general, electric forklifts are 75% less expensive to operate than propane and reduce maintenance costs per operating hour by 40%.[2]

Commercial Truck Electrification

While parked, long-haul truck drivers can plug into the grid instead of idling their truck or auxiliary engines to power their truck's heating, air conditioning, and accessories using truck stop electrification, or TSE, sites, which exist in almost every state.[3] With TSE, trucking operations can reduce fuel and maintenance costs, saving 40-70% on operating costs by eliminating fuel use during idling. Plugging in instead of idling engines also reduces local emissions and noise and provides a quiet, vibration-free rest stop for the driver. Moreover, since the truck is not idling, the engine life increases due to reduced wear and tear of engine parts, which leads to more productive life out of the trucks. The engine maintenance as well as oil and filter change intervals can be longer, also leading to improved productivity and lower downtime for the trucks.

A recent study on the impact of idling on fuel consumption and exhaust emissions for diesel vehicles and the available idle-reduction technologies indicates that the engine consumes more fuel during 10 seconds of idling than it does in restarting the vehicle. In addition, the study states that an engine runs at 30% efficiency when operating on the highway, but only at 3-11% during idling. A study published by Argonne National Laboratory indicates that a heavy-duty truck idles for six hours

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* Eight gallons per shift and two shift operation per day at roughly $4–$6 per gallon.

† Charge profile: 59.2A, 480Vac, and 6 hours of charge/day = 170.50 kWh/day; 12 cents/kWh.

per day, or 1818 hours per year, resulting in the equivalent of 200,000 extra miles of engine wear and 3,750 gallons of burned diesel fuel, adding operational costs of $4000-$7000 per truck per year.[4]

Commercial Induction Cooking Ranges and Electric Fryers

Electric induction cooking ranges offer many benefits to their users. Representing the latest, most efficient technology in their class, induction ranges transfer up to 90% of their energy to the cookware. These units heat quickly, offer very precise temperature control, and add a safety element by eliminating the need for an open flame. Because of these features, food cooks faster, which improves the productivity of the commercial kitchen.[5]

The electric fryers used in commercial kitchen facilities also offer productivity gains.[6] Electric fryers operate at lower temperatures, which saves energy, reduces oil breakdown, and uses less oil. Electric fryers also have faster pre-heat and recovery times than gas units and can go longer between oil changes, which is an important factor in the fast food industry. This allows more food to be fried in the same amount of time.[7]

Paint Curing and Drying

Thousands of industrial and consumer products require some sort of coating to improve durability, provide protection, or enhance aesthetic appeal. Most of these coatings are cured in inefficient and relatively slow natural gas convection ovens. Using electric technologies for the curing and drying process, such as ultraviolet curing or infrared curing, can improve efficiency and the speed of this process.

Ultraviolet (UV) Curable Coatings

In a manufacturing facility, the "finishing line" is the equipment and processes for preparing and coating a substrate, including equipment for washing and drying the part and for applying and curing the coating. Finishing lines are a complex array of sophisticated, finely tuned equipment.[8] While many coatings are cured using thermal processes, UV curing uses light energy from photons to create polymerization and chemical reactions, reducing or eliminating heat and increasing the productivity of the finishing line. UV curable coatings contain a catalyst called a photoinitiator that absorbs UV light and starts a photochemical reaction that causes an almost instantaneous cross-linking of the resins. Only the photoinitiator and exposure to UV light are required to start and complete the reaction.

UV coatings cure in a matter of seconds, rather than minutes or hours as with thermal processes, allowing for higher line speeds. In addition, it allows for faster startups and shutdowns and lower energy consumption. UV lamps turn on and off almost instantaneously and there is minimal energy or time lost waiting for the oven to come up to temperature to start or resume production, making standby modes unnecessary.

One example is a beverage packaging facility that saw increased productivity using UV curing. When a beer manufacturing company enlarged its sales territory, its beer can production facility sought to not only increase its production rates but also improve the can's finish. In the old method, the decorative inks and varnishes were cured in a gas convection oven, with pin chains conveying the can through the oven, curing the coatings in 12 seconds at 400° F and running at 1400 cans per minute. Interior coatings were then applied and cured in another gas oven. The thermal coating and curing system has several disadvantages—the length and speed of the pin chain conveyor limited the speed of the decorator, and the cans could be damaged if overheated in the convection oven. With the new method of using a UV curable coating, the conveying system can now handle much higher speeds and was able to increase the production capacity to 2000 cans per minute, a 43% increase in the production capacity with better product quality.[9]

Infrared Drying and Curing

Another electric technology used to cure and dry coating is infrared (IR) technology, which is a thermal process. IR heating is a versatile technology that can be used not just for curing paints but also for other heat transfer processes, such as drying textiles, heating plastics for thermoforming, comfort heating for warehouse employees, and snow melting for hazardous sidewalks. Whereas convection ovens first heat the air to transmit heat to a product, IR transmits heat through electromagnetic waves. Electric IR emitters can provide fine control of IR wavelength to match specific requirements of an application.

Outdoor South, located in Laurel, Mississippi, manufactures accessories such as brush guards, leg guards, and loading ramps for all-terrain vehicles (ATVs). The parts are fabricated from aluminum and steel plate, tube stock, and expanded metal and require a protective/decorative coating after final assembly. In the interest of improving the quality of the finish of their products, eliminating volatile organic compound emissions, increasing overall productivity, and minimizing floor space required for drying and curing, Outdoor South converted to using electric IR ovens for their coating process and saw significant productivity improvements.[10]

Prior to the conversion, the company used air-drying liquid enamels for coating the products, a very labor intensive process that required manual cleaning before painting, air-drying, and manually coating with air-atomized spray guns, after which the parts were placed on drying racks and cured in ambient conditions. Depending on temperature and humidity, the paint dried to touch in 30 to 60 minutes with complete cure of the coating taking anywhere from one to three days. Due to space limitations and the time necessary for cleaning, coating, and curing parts, only 40 to 50 racks of parts could be coated per day with the old painting process and significant amounts of overtime were sometimes necessary to keep up with production during periods of high humidity, when the curing process took longer.

The new method chosen switched to powder coating and use of electric IR ovens for pretreatment dry-off and curing of the powder coating. Outdoor South installed a new pretreatment system, a powder coating application system, and two short-wave electric IR ovens. The new pretreatment system is a three-stage power washer: cleaning and phosphating, an ambient temperature clear water rinse, and a sealing solution applied at ambient temperature. An electric IR dry-off oven heats the washed parts and provides complete drying in less than 90 seconds. The parts then enter the powder coating spray booth where a high gloss polyurethane powder coating is applied. The parts then travel through a two-zone electric IR curing oven where short-wave electric IR lamps heat the parts quickly, with complete cure accomplished in less than four minutes. This resulted in a significant productivity improvement—a 750-1500% productivity increase—compared to the previous drying times of 30-60 minutes. With parts hung from an overhead conveyor, the new line runs at four feet per minute in a continuous process versus the old "batch" method of painting. About 400 racks of parts can now be coated in one eight-hour shift compared to only 40 to 50 racks per day with the previous method, resulting in a ten-fold increase in productivity. And because electric IR is particularly well suited to frequent start/stop operations and short runs, increased flexibility on the coating line has been gained. The company can now coat all of its production in just two days per week whereas with the old method, painting was a full-time operation.

Induction Heating

Induction heating is a process heating method in which electrically-conductive materials are placed in a magnetic field generated by high-frequency alternating current flowing through an inductor. When the magnetic field intersects a workpiece made from any electrically-conductive material, it generates a circulating current that generates heat. Induction heating may be used to replace a wide variety of conventional process heating methods, such as fossil/electric furnace heating, salt/lead bath heating, and flame heating. It can be used for heating directly, for example, heat treating or melting conductive materials (typically metals), or indirectly by first heating a conductive material that transfers heat to the non-conductive material (such as plastics or chemicals).

One example of using induction heating is heat treating metal for railroad bearings by using induction heating systems.[11] Conventionally, a major railroad bearing manufacturer used a gas-fired rotary hearth furnace to heat precut billets for forging into railroad bearing races. However, increasing production demand for railroad bearings required additional heating capability, and excessive energy and maintenance costs were associated with the initial gas-fired furnace operation. As a solution, induction heating systems were installed as an alternative to the conventional gas fired furnace. In addition to reductions in energy and maintenance costs, the quick heating of parts using induction compared to natural gas heating reduces the exposure time of the hot metal surface to air, reducing the formation of metal oxide scales. Benefits of the new induction heating systems included overall cost savings per ton on the order of 25-30%, providing a payback period that ranged from 0.9 years to 1.25 years and a reduction in scale loss and scrap by 75% each, resulting in an increase in production rate and a significant decrease in product waste.

ONGOING EPRI RESEARCH

EPRI continues to expand its research assessing the potential benefits and opportunities of existing and emerging electric technologies. Through its efficient electrification program, EPRI will continue to develop a comprehensive benefit/cost methodology for screening efficient electrification technologies, conduct analyses of the economic and environmental benefits of the efficient electrification of energy services, assess the technical and realistic potential for deploying electric technologies, and establish a comprehensive technology pipeline to help accelerate technology adoption from early stage concepts to actual implementation through a series of field demonstrations.

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