# PROCESS HEATING

A Special Supplement to *Energy Matters*

## Process Heating Steering Committee

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## Process Heating Roadmap to Help U.S. Industries Be Competitive

Process heating is vital to improving industrial productivity, energy efficiency, and global competitiveness. Competitive pressures demand use of process heating technologies with improved performance, lower environmental impact, and greater flexibility. However, few companies have the resources to do the necessary research and development (R&D) to meet these goals. In response to industry's need, the process heating community, led by the Industrial Heating Equipment Association (IHEA) and DOE's Office of Industrial Technologies (OIT), has begun to develop a comprehensive plan for meeting industrial process heating needs. This plan is entitled "Roadmap for Process Heating Technology" and is intended as an industry guide on how to best implement process heating technology.

In November of 1999, thirty-five experts representing equipment manufacturers, end users, energy suppliers, and researchers met to address the issues facing industrial process heating. First, the participants defined key performance parameters and specific targets that are necessary to maintain their competitive position. Second, a list of barriers was identified, and third, specific goals were developed to address the barriers and achieve the set performance targets.

The highly diverse nature of industrial heating applications presented a significant challenge to the participants. In the end, the group agreed on the goals needed to ensure the competitiveness of U.S. industries in process heating over the next two decades.

The top priority R&D goals were:

- Advanced sensors that measure multiple emissions.
- Improved performance of high-temperature materials, including alloy composites.
- Predictive models of the process heating system.
- Improved methods for stabilizing low-emission flames.
- Heating technologies that simultaneously reduce emissions, increase efficiency, and increase heat transfer.
- Low-cost, low- and high-temperature heat recovery.

The top non-R&D goals were:

- Establish R&D and nonresearch priorities based on end-user input.
- Promote rational and consistent policies.
- Develop voluntary conventions and practices for equipment manufacturers.
- Develop incentives for purchase capital equipment utilizing new technologies.
- Expand the number of process heating applications using advanced technology.

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## Process Heating Roadmap

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- Foster the use of advanced enabling technologies in new process equipment.
- Develop the workforce by providing technical education starting at the elementary school level up through the post secondary level.
- Educate end users about information sources and equipment suppliers.
- Educate the public about industry and environmental issues via public relations activities and the media.

In October of 2000, a process heating steering committee was formed that consists of representatives from major industries and equipment suppliers. The committee created a plan that will help U.S. industries implement and demonstrate the best practices in process heating and to meet the near-term non-R&D goals. These activities will be carried out under OIT's BestPractices program. The R&D goals will be met through appropriate industries' R&D plans.

According to Dr. Arvind Thekdi of CSGI, Inc., who is also secretary of the process heating steering committee, "This cooperative effort will help U.S. industry remain competitive in the face of increasing pressure from the global marketplace."

Watch for process heating information in future issues of Energy Matters and learn about OIT's BestPractices activities in process heating. Because process heating savings can be reaped in locations throughout most industrial plants, it's likely that this information could improve your plant's bottom line. Look through this supplement for new ideas on process heating. ●

## The Big Picture on Process Heating

Consider the items we use every day—items such as decorative fixtures in our homes, the flatware we use for eating, and high-performance engine components in our cars. Although we use them in distinctly different ways, they all have a common manufacturing step that helps transform them into functional, finished goods. That step is process heating.

Process heating is vital to nearly all manufacturing processes, supplying heat needed to produce basic materials and commodities. Its use is extensive throughout industry—from the smallest manufacturers to Fortune 500 companies—to transform basic materials into the goods we use every day. Whether in the production of materials, such as steel, cement, and composites, or in the manufacture of value-added products, such as electronics, computer chips, cosmetics, and textiles, process heating plays an important part. Figure 1 captures many of the industries that use process heating as a manufacturing step.

With its wide and varied industrial use, process heating directly and indirectly affects the employment of an estimated 16 million people in the United States at more than 300,000 establishments with total annual sales and shipments of $3.8 trillion.

It is no wonder that heating processes (not including steam generation) consume about 5.2 quads (quadrillion Btu), which is nearly 17% of all energy used by industry. Heat derived from combustion of fossil fuels accounts for 92% of this energy; electricity use accounts for the remaining 8%. Industry's heavy reliance on these processes creates a critical need to optimize their performance for improved productivity,
energy efficiency, and competitiveness.

| Materials | Value-Added Product Areas | |
|---|---|---|
| • Steel | • Automotive Parts | • Gypsum |
| • Glass | • Appliances | • Foundry |
| • Basic Chemicals | • Speciality Steels | • Paint |
| • Ores and Minerals | • Food | • Computer Chip |
| • Copper and Brass | • Ship Building | • Jewelry |
| • Ceramic | • Textile | • Defense Equipment |
| • Petroleum | • Pipe & Tube | • Beverage |
| • Paper | • Fasteners | • Carbon & Graphite |
| • Aluminum | • Machinery | • Asphalt Paving |
| • Composite Materials | • Plastics | • Forging |
| • Cement | • Tools | • Cosmetic |
| • Precious Metal | • Powdered Metals | • Electronics |
| | • Weapons & Armaments | • Construction Materials |
| | • Farm & Heavy Equipment | • Aerospace Components |
| | • Paper Products | • Can & Container |
| | | • Wire |
| | | • Medical Products |
| | | • Rubber |

*Figure 1. Businesses and industries served by process heating equipment.*

### The Components of Process Heating Systems

Process heating systems are made up of five components including:

- Heating devices that generate and supply heat
- Heat transfer devices to move heat from the source to the product
- Heat containment devices, such as furnaces, heaters, ovens, and kilns
- Heat recovery devices

The system can also include a number of other support systems, such as sensors and controls, material handling, process atmosphere supply and control, emission control, safety, and other auxiliary systems. Figure 2 (page 6) illustrates the components of a process heating system.

In most applications, heat is supplied by one or more of four heating methods: fuel-fired heating, steam heating, hot oil/air/water heating, and electric heating. The heat is transmitted either directly from the heat source, or indirectly through the furnace walls, or through other means such as jets and recirculating fans.

For many industrial applications, 15%-85% of the energy supplied is used for heating the materials. Many factors, such as process temperature, equipment design and operation, and the type of heat recovery systems used, determine the energy

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## Seven Ways to Optimize Your Process Heat System

*By Arvind Thekdi, Executive Vice President, CSGI, Inc., Rockville, MD*

For most industries, process heating accounts for a high percentage of energy use, which means most plants can benefit from efforts to optimize their process heating systems. As natural gas prices continue to escalate, efficiency measures provide a means to save energy and curb energy costs. Beyond improving the bottom line, efficient process heating systems go a long way toward reducing emissions, such as nitrogen oxide ($NO_x$) and carbon dioxide ($CO_2$).

When it comes to optimizing heat process systems, an industrial facility has plenty of incentive to take action. So the question might not be "Should we make improvements?" but "Which improvements should we make?" One answer is to begin with the tried and true—the activities that have been done before with excellent energy-saving and pollution-reducing results. Consider those that can be easily accomplished using existing hardware and components and yield the best paybacks.

Efficiency measures such as these do exist. The table below is a guide to some process heating activities industrial companies can begin to implement in the near term. By addressing these changes to key process heating components today, your plant could be on its way to better system performance, and the plant-wide benefits will be apparent in the not-too-distant future. ●

### Process Heating: Best Bets for System Savings and Improvements

| Process Heating Component | Energy Saving Method | Energy Savings Potential (% of current use) | Typical Implementation Period | Typical Payback | Example Activities |
|---|---|---|---|---|---|
| 1. Heat Generation | Efficient combustion (burners) and operation of other heat generating equipment | 5%–25% | 1 week to 2 months | 1 to 6 months | Maintain minimum required free oxygen (typically 1%–3%) in combustion products from burners for fuel-fired process heating equipment.<br><br>Control air-fuel ration to eliminate formation of excess carbon monoxide (CO), typically more than 30–50 ppm, or unburned hydrocarbons.<br><br>Eliminate or minimize air leakage into the direct-fired furnaces or ovens. |
| 2. Heat Transfer | Design, operation, and maintenance of furnaces and heating systems to increase heat transfer from heat source to process or load | 5%–15% | 3 months to 1 year | 6 months to 1 year | Select burners and design furnaces that allow use of high convection or radiation in processes and loads.<br><br>Clean heat transfer surfaces frequently in indirectly heated systems, such as stream coils, radiant tubes, and electrical elements.<br><br>Replace indirectly heated systems, such as radiant tubes, and enclosed electrical heating elements, where possible. |
| 3. Heat Containment | Reduction of heat losses | 2%–15% | 4 weeks to 3 months | 3 months to 1 year | Use adequate and optimum insulation for the equipment. Conduct regular repair and maintenance of insulation. |
| 4. Heat Recovery | Flue gas heat recovery | 10%–25% | 3 to 6 months | 6 months to 2 years | Preheat combustion air.<br><br>Preheat and/or dry the charge load.<br><br>Cascade heat from exhaust gases to the lower temperature process heating equipment. |
| 5. Sensors and Controls | Improved process measurements, controls, and process management | 5%–10% | 1 to 10 weeks | 1 to 6 months | Develop procedures for regular operation, calibration, and maintenance of process sensors (i.e. pressure, temperature, and flow) and controllers. |
| 6. Process Models and Tools | Process models and design simulation to optimize equipment design and operations | 5%–10% | 2 weeks to 6 months | 1 month to 2 years | Set appropriate operating temperatures for part load operations to avoid long "soak" or overheating. |
| 7. Advanced Materials | Reduction of nonproductive loads | 10%–25% | 2 weeks to 3 months | 3 months to 2 years | Use improved materials, design, and applications of load support (fixtures, trays, baskets, etc.) and other material systems. |

## Indirect-Fired Kiln Conserves Scrap Aluminum and Cuts Costs

One successful example of a waste heat recovery application is at Wabash Alloys (formerly Roth Bros.), an aluminum recycler and provider of aluminum alloy in East Syracuse, New York. A demonstration project conducted at this plant by Energy Research Company (ERCo), of Staten Island, New York, involves a new energy-efficient kiln that heats scrap aluminum for reuse. This kiln has enabled Wabash to reduce metal loss and emissions of volatile organic compounds (VOCs) and, in addition, has reduced kiln energy use by more than half.

Aluminum scrap can be reused if it is decoated of oils and solid organics, such as rubber and plastics. ERCo's process uses an indirect-fired controlled atmosphere (IDEX™) kiln, which is better than traditional kilns at processing unwanted substances and reducing VOC emissions, product loss, and energy requirements. Thus, operational costs are also reduced. Figure 1 shows the IDEX kiln installed at Wabash Alloys.

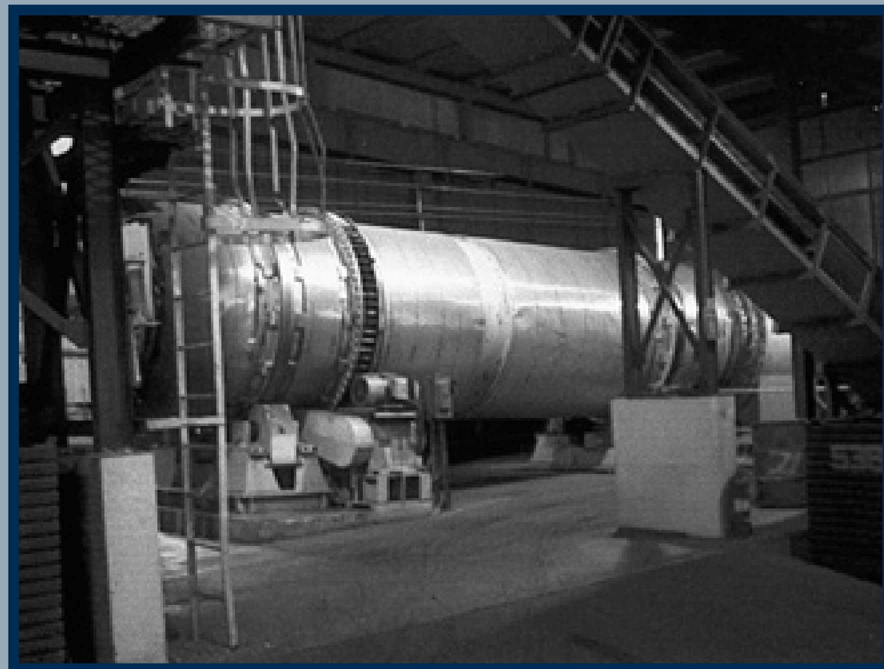

*Figure 1. IDEX kiln at Wabash Alloys.*

In the kiln, gases heated to 1500°F enter a center tube (Figure 2) and flow parallel to the scrap aluminum in a rotary drum while the center tube indirectly heats the scrap. The heat from the gases vaporizes the organics, but because the oxygen concentration is kept below the organics' flammability limits, no combustion occurs.

The gases are then passed to an incinerator that elevates their temperature to 1500°F. The organic vapors combust, which releases heat and destroys the VOCs. Part of the gases are vented and part are recirculated back to the kiln via a fan. The hot recirculated gases perpetuate the kiln heating and vaporization process.

Upon exiting the IDEX, the cleaned aluminum scrap is fed into a furnace where it is melted to produce specification ingots for die casters.

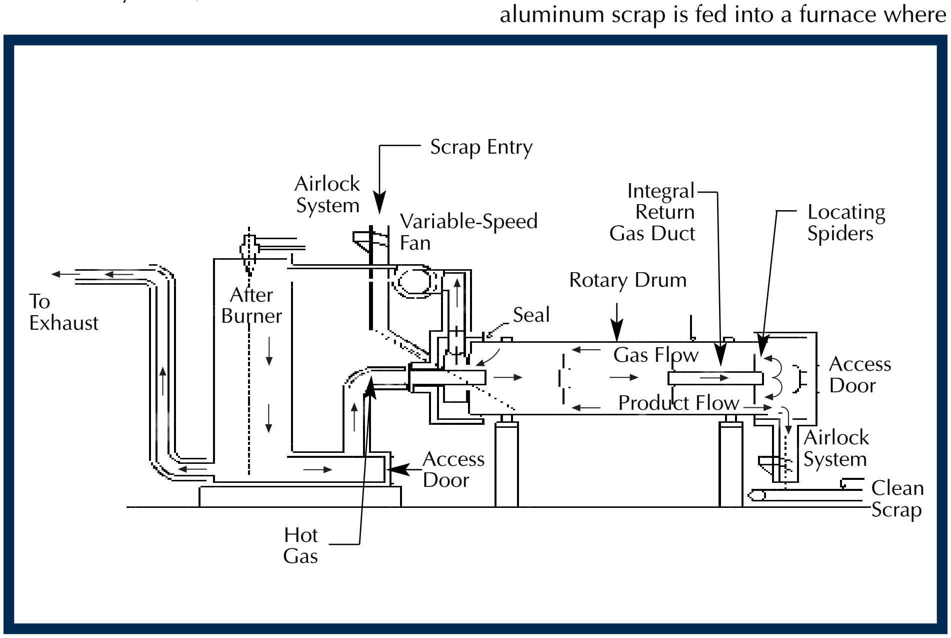


*Figure 2. Schematic of IDEX kiln.*

### Energy Savings

Figure 3 shows the measured specific energy use of the IDEX at Wabash Alloys, which is an energy savings of 55% over conventional equipment. Furthermore, the scrap is at 628°F after being processed by the IDEX; if this hot scrap is fed into the furnace, an additional energy savings of 370 Btu per pound of mass (Btu/lbm) is possible, for a total savings of 820 Btu/lbm.[1]

If air leaks are eliminated and preheated scrap is utilized, this technology could save 3 trillion Btu per year in the secondary aluminum market alone.

### Loss Reduction

Furnace measurements were also taken. With the IDEX making up only 20% of the furnace feedstock, metal loss was reduced from 8.2% to 7.5% on one set of furnace data runs. Using this data, it is estimated

[1] Due to scheduling problems, Wabash Alloys does not feed the scrap immediately into the furnace, and so does not take advantage of the preheating.

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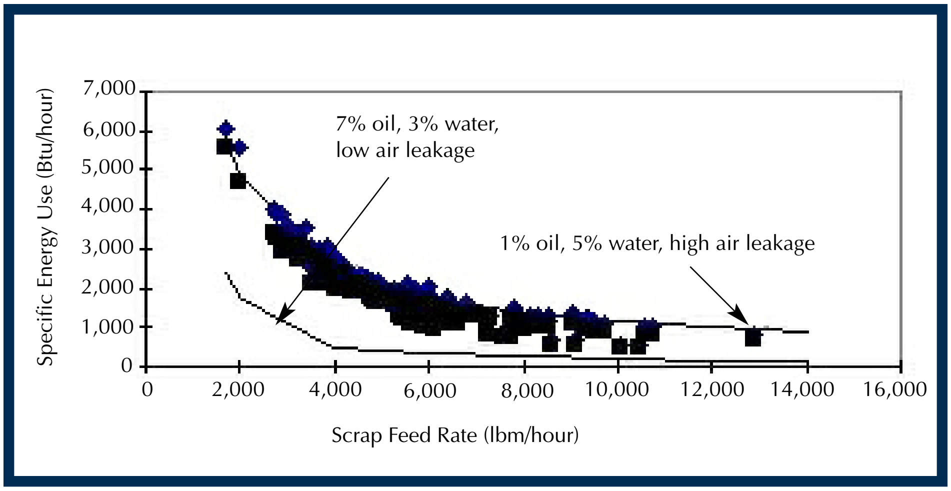


*Figure 3. IDEX specific energy use.*

that loss could be reduced by 2.8% for a metal yield gain of 2.35 million pounds per year per unit.

In Figure 4, scrap metal that has been processed using a conventional dryer is being charged into the furnace. Flames are clearly visible, indicating the presence of organics that are burning and oxidizing the metal. In Figure 5, the scrap charge has been processed in the IDEX. The only flames visible are those left over from the previous charge.

Neal Schwartz, who was general manager of Roth Bros. at the time of the installation, said, "The quality of the scrap that comes out of the IDEX is much much better…[when] we were using the older technology, scrap would burn and smoke... now we get a better product and there is no smoke at all, and we are really very happy with it."

**Emissions Reduction**

Emission measurements were taken from the IDEX by Galston Measurement of Syracuse, New York. Nitrogen oxide ($NO_X$), sulfur dioxide ($SO_2$), VOCs, and particulates were measured to be at 19%, 2%, 2%, and 6%, respectively, compared to New York State's Department of Environmental Conservation standards.

The EPA has proposed emissions regulations for scrap dryers.[2] The IDEX meets and betters these EPA-proposed standards in all measured categories.

**Project Participants**

This project was funded by DOE's National Industrial Competitiveness through Energy, Economics, and Environment (NICE[3]) program and the New York State Energy Research and Development Authority. Other participants in the project included O'Brien & Gere, of Syracuse, who built and installed the equipment, and two technology marketers—Gillespie & Powers of St. Louis, Missouri, and Stein Atkinson Stordy, of Wolverhampton, United Kingdom.

By saving energy, reducing emissions, improving product quality, reducing solid waste, and decreasing operating cost, the IDEX kiln clearly has a bright future in the aluminum industry.

*For more information on this project, contact Bob DeSaro at (718) 442-2725 or rdesaro@er-co.com.*

[2]EPA CFR Part 63 [IL-64-5807;FRL].

*To read a similar article about a heat recovery application involving high-temperature annealing in the steel industry, see the Energy Matters Extra Web site at www.oit.doe.gov/bestpractices/explore_library/emextra/.*

*Figure 4. Conventionally processed scrap being fed to the charging well.*

*Figure 5. Scrap that has been processed by the IDEX kiln sitting in charging well.*

## The Big Picture on Process Heating

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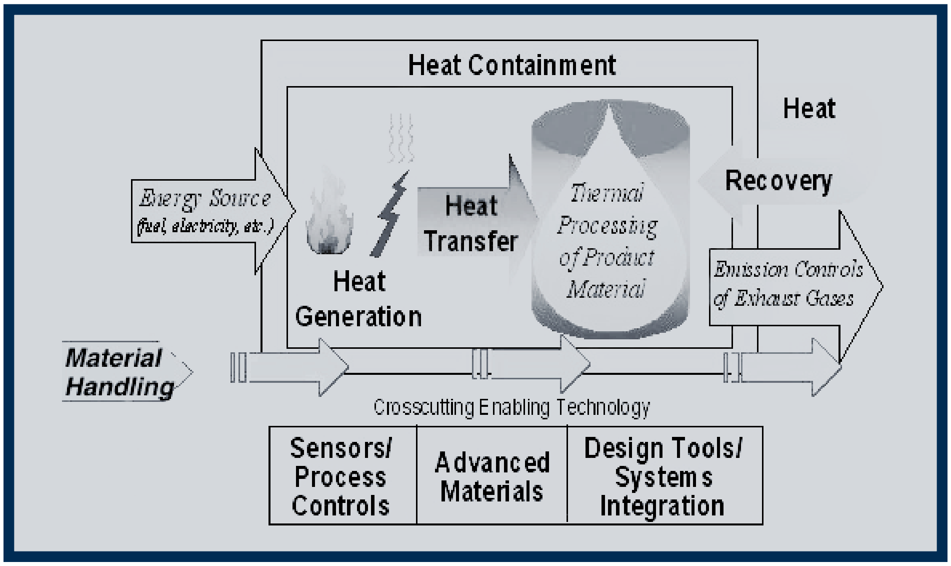


*Figure 2. The components of process heating systems.*

efficiency of a process heating system. Hence, industrial process heating systems offer opportunities to save significant amounts of energy.

**Process Heating Energy Consumption**

Process heating equipment is operated over a broad temperature range, from 300°F to as high as 3000°F. Consequently, these processes consume large amounts of energy. In fact, energy costs for process heating represent 2%–15% of a product's total cost.

In U.S. industry, process heating accounts for more direct energy use than any other processes that consume energy during manufacturing. Other energy-consuming operations, such as steam generation and cogeneration, include essentially the same components, as shown in Figure 2, and often supply steam or hot water used for process heating.

Over the last two decades, U.S. industry has made significant improvements in process heating efficiency, which has resulted in a reduction of energy per unit of production. However, U.S. industry's total energy use for process heating is expected to increase. Process heating R&D activities and application of process heating best practices can contribute to significant reductions.

Across industries, process heating is used for nine generic industrial operations: fluid heating, calcining, drying, heat treating, metal heating, metal and nonmetal melting, smelting/agglomeration, curing and forming, and other heating. Factors such as cost, availability, process, and emission requirements determine which energy source is used. Figure 3 shows the most commonly used energy sources for each operation.

Combustion-related emissions, such as nitrogen oxide ($NO_X$), volatile organic compounds (VOCs), and particulates, are closely related to energy use in process heating. In the last 20 years, the combined effects of advancements in processes, improvements to equipment design, and gains in thermal efficiency have helped to reduce environmental impacts from these emissions. As these advancements continue and efficiency levels improve, so will emission reductions.

**Potential for Savings**

Today, overall thermal efficiency of process equipment varies from 15% to 80%, compared to the thermal efficiency of steam generation, which varies from 65% to 85%. Lower efficiency levels for process heating opens the door for significant energy savings. The greatest potential is in the higher temperature range processes, as the margin for improvement is large and the returns are greater. With the use of advanced technologies and operating practices, process heating energy consumption could be reduced by an additional 5%-25% within the next decade.

Together, OIT and the process heating community will continue to develop and carry out R&D programs to guide industry and help achieve major improvements in heat processes over the next 20 years. However, manufacturing companies can embark on heat process efficiency measures—right now—in their own operations. Take a look at page 3 of this supplement for examples of activities that offer good results with limited effort. In addition, OIT's BestPractices Web site offers many resources and tools to help you assess and improve systems throughout the operation—systems like motors, steam, and compressed air, which may all be connected to heat processes in the plant. Explore the Web site at **www.oit.doe.gov/bestpractices.** ●

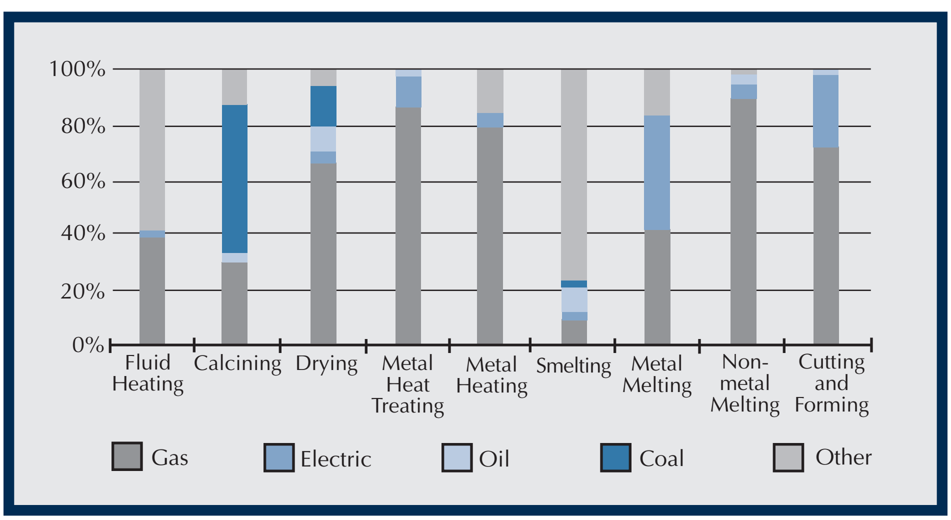


*Figure 3. Energy sources for common industrial processes that require process heating.*