Summary

An oven can be simply described as a fully enclosed, insulated chamber used to heat food. There are many variations of this basic concept in the commercial kitchen, but each type of commercial oven cooks by controlling the temperature and/or humidity of the oven cavity. The oven's versatility makes it useful in many types of food service operation.

Efficiencies vary between the different types of ovens and fuel sources. Standard-efficiency gas ovens are typically 30 to 40 percent energy efficient; high-efficiency gas ovens between 40 and 50 percent. Electric efficiencies run between 50 and 80 percent.

This end-use briefing offers a quick tutorial on the common types of ovens in commercial food service operations. It covers the following topics:

- **Definitions of key terms**, such as standard and convection.
- **Description of common oven types** and their operational characteristics.
- **Description of new oven technologies** and their operational characteristics.
- **Typical applications** of each type of oven.
- **Key field observations** to help assess operational efficiency and energy conservation opportunities.
• References to other documents that provide detailed information on the topics in this briefing.

## Definitions of Key Terms

### Air Impingement:
Jets of air are directed onto the food product using a ported manifold.

### Atmospheric Burner:
A burner which jets gas and air through a hole (“burner port”) at which point it mixes and is ignited. This “Bunsen” type burner shows a blue flame when properly adjusted.

### Conduction:
A cooking process in which heat is transferred to the food via direct contact with a heated medium (e.g., ceramic hearthstone, firebrick or composite hearth.)

### Convection:
A cooking process in which currents of hot air transfer heat to the surface of the food. Convection ovens use fan(s) to circulate hot air in the oven cavity.

### Cooking Energy Efficiency:
The ratio of the quantity of energy absorbed by the specified food to the quantity of energy input to the oven during a cooking energy efficiency test, expressed as a percent.

### Direct Fired:
Describes gas ovens which route the combustion products from the burners through the cooking cavity, transferring heat directly to the food from the hot gases.

### Forced Convection:
Convection induced in the oven cavity by fans or blowers.

### Indirect Fired:
Describes gas ovens which route the combustion products around the bottom, sides and top of the oven without entering the cooking cavity. The oven cavity walls of indirect fired ovens become hot and heat is transferred to the food by either convection or forced convection.

### Idle Energy Rate:
The rate at which an empty oven uses energy to maintain its cavity temperature at the thermostat set point (e.g., 350°F).

### Infrared Burner:
A burner made of porous ceramic plates or metal screens. Combustion of premixed air and gas takes place on the burner surface, which can reach 1800°F. The high surface temperatures cause the material to emit radiant heat. Up to 50 percent of the energy in the gas can be converted to radiant heat.

### Natural Convection:
Convection created in the oven cavity due to the natural movement of hot air heated by burners, elements or heated cavity walls (i.e., without the use of fans or blowers).

### Oven Capacity:
Maximum amount of food that can be cooked at one time (e.g., 6 12"-diameter pizzas, 40 pies, 20 to 40 sheet pans).

### Oven Cavity:
The cooking zone, chamber or compartment in an oven.

### Radiant heat:
Hot surfaces emit radiant heat. In ovens, the heat radiated by burners, elements or the heated cavity walls moves towards the food.
• **Rated Input:** (Also “Nameplate Input”) The maximum rate of energy consumption for an appliance.

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### Conceptual Overview

Commercial ovens are available for use with gas, electricity or liquid propane and come in many sizes.

An oven heats food by surrounding it with hot air. Heat is transferred to the food via convection, conduction, radiation and steam, either singularly or in combination. In standard ovens the burners or elements heat the air inside the cavity causing natural convection currents which transfer heat to the surface of the food. What the industry calls a “convection” oven employs motorized fans or blowers to create forced convection currents in the cavity; this cooks the food faster while maintaining uniform heating.

Heat may be transferred to a oven either indirectly or directly. In indirect-fired ovens, the hot combustion products of the gas heat the bottom, sides and top of the oven without entering the cooking cavity. In direct gas-fired ovens the hot combustion products are directed through the cooking cavity rather than around the cavity. Heat is transferred directly from the hot gases to the food.

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### Common Oven Types and Categorization

Ovens fall into two common categories: standard (or natural convection) and forced convection. Standard and forced convection ovens are divided into sub categories (rack, combination, conveyor, rotisserie, etc.). The matrix in Table 1 presents the characteristics of each sub category, along with common use and customer application.

#### Standard

Standard ovens use natural convection (hot air currents) and radiant heat to cook food products. These ovens can be used for nearly all types of food preparation. Because they do not use blowers or fans to move air inside the oven cavity, standard ovens are used for precision-baking sensitive pastry products such as meringues, cream puffs and pastry shells. Standard ovens are the least expensive to purchase, but they are not as fast-cooking or flexible as forced convection ovens.

Standard ovens usually have simple controls, limited to a thermostat and a selector that allows the oven to bake or broil. Modulating thermostats, which adjust the burner incrementally, are most common.

**Range Oven**

The most common standard oven is the range oven. Range ovens are part of the base of a rangetop, and are the familiar type of oven seen in most residential applications.

Gas range ovens are heated with atmospheric gas burners located directly below the oven cavity. The flue gases are routed around and/or through the cavity. In electric ovens the elements are placed in the top and bottom of the oven cavity, where they add both radi-
Ant and convective heat; they also may be placed underneath the oven cavity.

**Deck Oven**

These ovens have a flat, wide cavity. The floor of the cavity is referred to as a deck, and it is usually possible to place pans or the food product itself directly on the deck surface. These ovens are usually freestanding, and may consist of one to four stacked compartments.

Compartment size and construction vary. Manufacturers list deck ovens by intended use. Baking and roasting compartments may be combined into one oven with multiple cavities; the baking compartments are about half the height of roasting compartments (7” vs. 15”). Specialized deck ovens for baking pizza may have modified decks and/or dampers to adjust temperature.

Deck ovens also can be used to cook a wide variety of other foods; the limiting factor is the height or thickness of the food product.

**Convection**

Convection ovens force air through a motorized fan (or blower) which blows heated air throughout the oven’s cavity. The speed of the fan affects cook time and uniformity, as does the pattern of airflow through the interior. Gas convection ovens are available with single or multiple burners. Burners are usually located at the bottom of the oven cavity, or between the cavity and the insulated oven wall. Until recently, most gas convection ovens have used atmospheric rather than infrared burners.

Most gas convection ovens are indirect-fired. Manufacturers differ in how they route the flue gases and how they mix them with cavity air. Gas burners may be protected from air currents by an arrangement of baffles, and the flue gases directed around or through the cavity. Alternatively, the flames and flue gases may be directed into tubes that act as heat exchangers and vent into the flue.

Forced convection ovens come in full-size or half-size capacities, depending on whether they are dimensioned to accept standard full-size 18 x 26 x 1” or half-size 18 x 13 x 1” sheet pans. Full-size ovens have large interior cavities capable of handling up to six full-size pans. Half-size models accommodate up to five half-size pans. Countertop and range type convection ovens are also available, as are high-capacity roll-in or rack ovens. The convection principle has also been applied to conveyor and rotisserie ovens.

In general, convection ovens offer more control over cooking than standard ovens. Convection ovens generally use accurate electronic sensors and thermostats. Many gas models feature electronic ignition and controls. Also, most of the newer gas and electric models have programmable cooking computers. Some ovens allow the user to control cooking by regulating fan speed as well as temperature, humidity and cooking time.

**Rack Oven**

Rack ovens are tall stainless steel boxes. The rack oven is capable of producing uniformly cooked products in high volume. They typically have a capacity of 20 to 40 standard sheet pans.
<table>
<thead>
<tr>
<th>Oven Type</th>
<th>Standard</th>
<th>Convection</th>
<th>Rack</th>
<th>Combination</th>
<th>Conveyer</th>
<th>Rotisserie</th>
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<td></td>
<td>Range</td>
<td>Deck/Pizza</td>
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<td>15 - 100</td>
<td>125 - 375</td>
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<td>Electric (kW)</td>
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<td>6 - 12</td>
<td>2 - 40</td>
<td>10 - 63</td>
<td>35 - 45</td>
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<td>1-3 Cavities</td>
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<td>1 Cavity</td>
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<td>deep x 30” high</td>
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<td>Half-Size: 6</td>
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Table 1: Oven Types, Common Uses and Typical Customer Applications
Pans are loaded into a metal rack which is rolled into the oven. Inside the oven, a motorized lift revolves the rack for even cooking. Rack ovens use forced convection and many have the ability to inject steam into the cavity to enhance shine and crust on baked goods.

**Combination Oven**

Combination ovens are convection ovens that include a steam generator. The oven can be operated as a convection oven, as a pressureless steamer, or in “combination” mode.

Combination ovens can hold either traditional sized half- and full-sized sheet pans or steam pans. They start with smaller countertop or half-size models, move towards full-size combination ovens and extend to large, floor-mounted, full-sized units that accept up to 20 standard full-size sheet pans. Large capacity roll-in rack models are also available.

Electric combination ovens dominate the market place, however recently several manufacturers have introduced gas alternatives. Many gas models are now available.

**Conveyor Oven**

Essentially, conveyor ovens are a rectangular housing containing a baking cavity or chamber which is open on the two opposite sides. A conveyor system carries the product through the baking chamber on a wire rack. Some conveyor ovens can be outfitted with multiple conveyors so that products may be sent through the oven at different speeds.

Oven controls adjust both the heat input and speed of the conveyor. Newer conveyor oven designs may incorporate multiple cooking zones within the cooking chamber, with three cooking zones being typical. Some conveyor ovens have a hinged glass door along side of the chamber to allow loading and unloading of food.

Conveyor ovens are available using four different heating processes: infrared; natural convection with a ceramic baking hearth; forced convection; or a combination of infrared and forced convection. The ovens are available in many different sizes and configurations. Most ovens can be stacked up to three units high, significantly increasing production capacity without requiring increased floor space. Gas leads in this market.

**Rotisserie Oven**

Rotisserie ovens are designed for batch cooking, with individual spits arranged on a rotating wheel or drum within an enclosed cooking cavity. The heat source may be a gas burner or electric elements, and some rotisseries incorporate high-wattage quartz lamps for display and/or browning.

For gas rotisserie ovens a number of gas-fired burner systems are available. Single heat-source systems include atmospheric flame type, radiant and infrared. There also are dual burner systems that combine infrared with an open flame and radiant heat. Most gas models feature electronic ignition systems.

Rotisserie ovens range in size from high-volume floor models to space-saving countertop models. Most models are equipped with basic time and tem-
perature controls, optional cook-and-hold controls, or more sophisticated control packages with programmable channels.

State-Of-The-Art Oven Technologies

Infrared Burners

More efficient infrared burners are replacing the traditional atmospheric burners in gas ovens. An infrared/forced convection oven combines the penetrating heat of infrared radiation with convection to sharply reduce baking time compared to natural convection ovens.

Air Impingement

Air impingement is a relatively new technology applied to conveyor and some rotisserie ovens. Air impingement typically uses a ported manifold to direct jets of air, or “fingers,” onto the product’s surfaces. The “fingers” of air blow away the layer of air and moisture that insulates the food, thus increasing the speed of the cooking process.

Quartz Halogen Lamps

Quartz halogen lamp ovens use a combination of infrared energy and visible light to cook food. The ovens use radiant heat to brown and crisp the exterior as would a conventional oven. The lamps start heating instantly, thus have no preheat time, and remain off when the oven is in idle mode.

Conduction

A recent entry into the market place is an electric cook-and-hold conduction oven which circulates heat transfer fluids through the oven’s heat transfer plates. The heat is conducted directly through the pans to the food. This method of heat transfer, according to the manufacturer, allows food to be brought evenly to a cooked state without burning or drying.

Combination Convection Microwave

A few oven manufacturers are using a modified impingement system that propels hot air directly down onto the food, then pulls it around and underneath the product. This oven is frequently supplied with a built-in microwave to further speed the cooking process.

Some manufacturers are combining “smarter controls” with the ovens that use air impingement and microwave cooking technologies. Among the innovations are computer-controlled focusing of the hot-air impingement above and below; a non-rotating cooking service, which means that the whole oven can be used to prepare food; and an innovative microwave technology which will permit the use of metal trays and pans.

A large microwave oven manufacturer is being touted as producing the first commercially approved compact oven for food service use. It packs a “double whammy”, offering 1000 watts of microwave energy and 2,200 watts of con vected air. With this combination comes a host of usage options: browning,
baking, steaming, sautéing, cooking and roasting.

**Typical Customer Applications**

Operators specify ovens based on a variety of factors including its function and versatility, production capacity, temperature uniformity, and first cost. Table 1 shows the typical applications of ovens in food service operations.

**What to Look for in the Field**

- **Preheat Time**: Most ovens require preheating for half an hour or less. Ask the operator how long he/she usually allows the oven to preheat to determine if there is an opportunity to minimize the oven on time.

- **First use**: Is there a regular time each day when the oven is first used to prepare food? Note this time as well as when the oven is usually turned on.

- **Last Use**: Is there a regular time when the last load of product is prepared? Note this time as well as when the oven is usually turned off.

- **Long Idle Periods**: Note any long periods (e.g. between last lunch and first dinner prep) when the oven is idle for two or more hours.

- **Food Product**: What foods are cooked in each oven, and at what settings? For combination ovens, determine if the steam mode is used and if so, for which food products?

- **Nameplate rating**: Energy input ratings on the nameplate of range ovens typically list the combined input of the range oven with the burners or elements comprising the range top.

- **Oven sized to match production volume**: Oversized oven capacity can cost the facility money by wasting both energy and space.

**Tips for Efficient Operation**

- **Turn it off**: Because it can take up to half an hour to preheat, the oven can’t be turned off when it is used sporadically. But if you can identify a continuous two-hour period when there is no use on the oven, the operator can save up to $400 each year by turning it off every day during that period.

- **Start-up and shut-down schedule.** Sometimes employees simply walk down the line of appliances in the morning, turning on every one, hours before they may be needed. Identify when the appliance is first used in the morning, and turn it on just long enough beforehand to allow for an appropriate preheat.

  Likewise, turn the oven off after its last use of the day, not some time later as part of cleanup. Turning an oven off for an extra hour each day can mean savings of $40-$200 a year, depending on the oven.

- **Don’t use steam if you don’t need it**: Often combination ovens are used in
combination mode (i.e., forced convection plus steam) when convection mode would be just as effective. Vaporizing water for steam may increase the energy use of these ovens by as much as 100%.

References to More Information


