



Energy efficiency opportunities in the U.S. commercial baking industry



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ABSTRACT

Commercial bakery products in the United States such as breads, rolls, frozen cakes, pies, pastries, cookies, and crackers consume over \$870 million of energy annually. Energy efficiency measures can reduce the energy costs of significant energy processes and increase earnings predictability. This article summarizes key energy efficiency measures relevant to industrial baking. Case study data from bakeries and related facilities worldwide are used to identify savings and cost metrics associated with efficiency measures. While the focus of this paper is on U.S. bakeries, findings can be generalized to bakeries internationally. A discussion of energy management systems is provided and how energy efficiency measures savings can be sustained. Energy and plant managers at bakeries can use this information to cost-effectively reduce energy consumption while utilities and policy makers can apply the findings to energy efficiency program design.

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1. Introduction

Manufacturers worldwide are considering energy efficiency measures as a way to mitigate the impact of volatile energy markets, growing competition, and regulation of greenhouse gas (GHG) emissions. As part of an overall environmental strategy, implementation of energy efficiency measures often leads to reductions in GHG emissions and other air pollutants. Investments in energy efficiency are a sound and key business strategy in today's manufacturing environment. Additionally, manufacturers are implementing energy management systems as a way to sustain gains realized from energy efficiency measures. Improvements in energy performance translate into continual increases in product quality, production, and process efficiency.

Within the United States, commercial bakeries produce fresh and frozen breads, rolls, cakes, cookies, and other pastries. The North American Industry Classification System (NAICS) code system divides the commercial baking industry into three sectors. These sectors are listed in Table 1 along with the primary products produced by each, which highlights the diversity of products manufactured by the industry.

Modern large commercial bakeries use highly automated processes during production. When operating at full capacity, a single large bread bakery may produce up to 136,000 kg of over 100 different varieties of bread and other bakery products per day.

All physical mixing and blending of ingredients, as well as the working and dividing of the dough, is performed mechanically. Most dough batches are mechanically conveyed through each step of the baking process, from the initial dividing through the final slicing and bagging, with minimal handling (U.S. EPA, 1992).

Table 2 summarizes key economic and energy purchase data for the two major segments of the U.S. baking industry disaggregated by five digit NAICS code. Employment in 2010 exceeded 230,000 and the total value of product shipment exceeded \$53 billion – numbers that underscore the significant contributions made to both U.S. employment and economic output. Over \$870 million was spent on purchased fuels and electricity in 2010, or roughly 1.6% of the total value of product shipments. Electricity accounted for 63% of purchased energy and the remaining 37% was comprised mostly of natural gas. While energy costs represented only 4% of total cost of materials, the sheer amount spent on purchased energy suggests that energy efficiency can play a critical role in reducing operating costs.

Energy efficiency measures can be used to reduce the cost and volatility of purchased electricity and fuels. This paper provides an overview of energy use and consumption in the U.S. baking industry and identifies the significant energy using processes and related systems. Specifically, proven energy efficiency measures are summarized for the following plant systems: boilers used to produce steam for fermentation, ovens used to bake product, coolers and freezers used to chill and freeze product, and cleaning systems used to wash pans and other equipment. Specific energy consumption can vary widely among different plants, depending on the types of product manufactured and the condition of

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Table 1
Key products of the U.S. commercial baking industry.

Subsector description	NAICS code	Key products
Commercial bakeries	311812	Bread, rolls, cakes, pies, other pastries
Frozen bakery products	311813	Frozen cakes, pies, and other pastries
Cookies and crackers	311821	Cookies and crackers

installed equipment. Additionally a brief description of energy management best practices is provided. Properly implemented, an energy management system can ensure savings from implemented energy efficiency measure are sustained. Energy and plant managers at U.S. baking facilities can use this information to reduce energy consumption in a cost-effective manner while maintaining the quality of products manufactured. Additionally, utilities and policy makers can use these results to target energy efficiency programs and incentives to the baking industry.

2. Methodology

Energy use and consumption within the U.S. baking industry was determined by surveying academic literature and government reports, and conducting field visits. Available literature is limited in quantity but provides a clear picture of the significant energy uses and related energy consumption levels. Three commercial bakeries, which produce a range of products including rolls, frozen pies, biscuits, cookies, and crackers, were visited. Interviews with energy managers at these facilities were conducted, which focused on the use and consumption of energy in bakeries and confirmed identified energy use and consumption analysis data.

Energy efficiency measures for systems related to the significant energy using processes were identified. When possible, quantified energy, energy cost, or payback data are presented. Data quantifying the savings and costs of energy efficiency measures have been drawn from multiple sources including case studies, government reports, trade journals, site visits, and the U.S. Department of Energy supported Industrial Assessment Center (IAC) database (U.S. DOE, 2012). Measures without savings values are presented as well. For these measures, absolute savings values are difficult to determine, as they are very dependent upon current bakery practices. While savings and cost values presented in this paper will vary plant to plant they provide indications of the practicality and cost-effectiveness of the identified measures in a real-world plant setting.

3. Energy use and consumption in U.S. commercial bakeries

In their simplest form, most bakery products (bread, rolls, cookies, crackers, etc.) have similar ingredients consisting predominantly of flour, water, and salt. Minor ingredients are used to change attributes such as volume, crumb softness, grain uniformity, silkiness of texture, crust color, flavor and aroma, softness retention, shelf life, and nutrient value (U.S. EPA, 1992). Leavened

products contain yeast that is developed in various ways depending upon the production method and recipe. Products that require dairy ingredients require special sanitation practices.

Fig. 1 shows generic production process diagrams for each of the three bakery subsectors disaggregated by NAICS code as identified in Table 1. NAICS code 311812 (commercial bakeries) is divided into two parts: (1) breads and rolls, and (2) cakes and pies. As previously described, the figure shows that most bakery products are produced with the same core processes: mixing, shaping or forming, baking, cooling or freezing, and packaging. Process steps specific to one of the different generic product types are also seen: fermentation, proofing, slicing, pan washing, and shortening storage. Yeast based products require time to develop, necessitating fermentation and proofing stages. Some bread and roll products are sliced before packaging. Other products require finishing work, adding decorative items or coatings, after baking and cooling. Frozen products are quickly frozen rather than cooled to room temperature (Sikirica et al., 2003).

Table 3 lists energy intensity values (J/g of finished product) for processes used in each of the baking subsectors. The values listed are representative of the energy required to produce a typical product; however, product-to-product and plant-to-plant variations will occur. Additionally, each table lists the relative percentage of energy required for a given process step as a function of the total subsector energy requirement.

Energy consumption is most concentrated in the fermenting, baking, freezing, and pan washing processes (greater than 10% of total subsector energy consumption each). The baking process typically consumes the largest amount of energy, ranging between 26% and 78% of total subsector energy. Only in the case of frozen products is baking not the largest portion of energy. Baking represents 78% of the energy requirement for cookies and crackers, a subsector that does not require the use of pan washing or a fermentation and proofing process. Breads and rolls as well as cookies and crackers – products that require significant baking times – require more energy per unit of production than frozen and non-frozen cakes. In the case of frozen products, the freezing process consumes the most energy, exceeding baking. When used, pan washing also consumes a consistently large amount of energy.

The four processes identified typically employ one type of significant energy using system. The fermenting process typically utilizes steam from a steam system. The baking process is closely linked to the type and operation of oven installed, but typically direct-fired natural gas ovens are used. The freezing process is directly associated with a freezer and frozen storage system. The pan washing process is typically dependent upon the use of hot water though in this paper the process is included within the larger envelop of cleaning systems.

4. Energy efficiency measures

Key energy efficiency measures are presented that can be implemented to improve energy performance for the major energy using systems described above: steam systems, ovens, cooling and freezing, and cleaning. These energy efficiency measures were

Table 2
Summary of economic and energy purchase data, 2010.

NAICS	Description	Employees	Costs (\$1,000,000)			Value of shipments (\$1,000,000)
			Materials	Purchased fuels	Purchased electricity	
31181X	Bread and bakery product manufacturing	187,309	12,824	224	384	33,138
31182X	Cookie, cracker, and pasta manufacturing	45,453	8762	95	169	20,282
Total		232,762	21,587	319	553	53,420

Source: U.S. Census (2011).

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