The State of Energy-Consumption Legislation for Commercial Refrigeration Applications

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About Emerson

Emerson (NYSE: EMR), based in St. Louis, is a global leader in bringing technology and engineering together to provide innovative solutions to customers through its network power, process management, industrial automation, climate technologies, and appliance and tools businesses. For more information, visit **GoToEmerson.com**.

About Emerson Climate Technologies

Emerson Climate Technologies, a business of Emerson, is the world's leading provider of heating, ventilation, air conditioning and refrigeration solutions for residential, industrial and commercial applications. The group combines best-in-class technology with proven engineering, design, distribution, educational and monitoring services to provide customized, integrated climate-control solutions for customers worldwide. Emerson Climate Technologies' innovative solutions, which include industry-leading brands such as Copeland Scroll™ and White-Rodgers, improve human comfort, safeguard food and protect the environment. For more information, visit **EmersonClimate.com**.

About Copeland Corporation

Copeland Corporation, part of Emerson Climate Technologies, is the world's leading compressor manufacturer, offering more than 10,000 compressor models in a full range of technologies, including scroll, reciprocating and screw compressor designs. A pioneer in the HVACR industry, the company led the introduction of scroll technology to the marketplace. Today, more than 50 million Copeland Scroll compressors are installed in residential and commercial air conditioning and commercial refrigeration systems around the world. Copeland is headquartered in Sidney, Ohio. For more information, visit **copeland-corp.com**.

Copeland®

EMERSON™
Climate Technologies

Emerson Climate Technologies

Emerson Climate Technologies is committed to working with original equipment manufacturers to provide global solutions to improve human comfort, safeguard food and protect the environment. Emerson helps the industry meet the increasingly stringent energy-consumption guidelines by participating in the development of these standards, communicating standards and trends, providing the most energy-efficient components and offering energy-reducing design and consultation services.

Emerson Climate Technologies™ products play a substantial role in energy consumption of commercial refrigerators and freezers. For decades Emerson's Copeland Corporation has been developing new energy-efficient compressor technologies. The next generation of fractional-horsepower hermetic compressors recently released by Copeland includes design improvements that make it the most energy-efficient offering in its class. For both low-temperature freezer and medium-temperature applications, Copeland offers the highly reliable and energy-efficient semi-hermetic compressor, in addition to its full offering of hermetic compressors.

Emerson's Integrated Products offers a wide variety of engineered condensing units using Copeland® hermetic or semi-hermetic compressors. These condensing units are custom engineered with the perfectly matched condenser and professionally manufactured to minimize thermal inefficiencies, resulting in highly energy-efficient systems.

Emerson's Flow Controls offers a full range of thermo expansion valves. These intelligent devices sense the amount of cooling required at each moment throughout the refrigeration cycle and supply exactly that amount. In this way, the thermo expansion device minimizes energy wasted by over-supplying capacity, while limiting the duration of the energy-consuming on-cycle.

Emerson's Computer Process Controls offers a range of refrigerator, freezer and case controls that intelligently monitor the refrigeration system, including the critical defrost periods. These controls ensure that sufficient heat is sent to the evaporator to defrost it, but no excess energy-consuming heat is sent after defrost is complete. Computer Process Controls is constantly refining and releasing new devices that minimize the heat and energy required by glass doors to keep them clear of fog after the doors are opened and closed, as well as devices that minimize the heat required to prevent sweat around door gaskets.

Emerson's Retail Services offers end-users the ability to monitor all refrigeration and air conditioning systems in a facility to ensure they are operating at peak efficiency, reducing total energy consumption for the end-user.

Finally, Emerson's Design Services Network is an approved laboratory for California Energy Commission testing of commercial refrigerators and freezers; it has a full staff of engineers available to help manufacturers reduce energy consumption and get products approved for sale.

More detailed descriptions of all Emerson Climate Technologies products and services can be found at **EmersonClimate.com**.

About the Author

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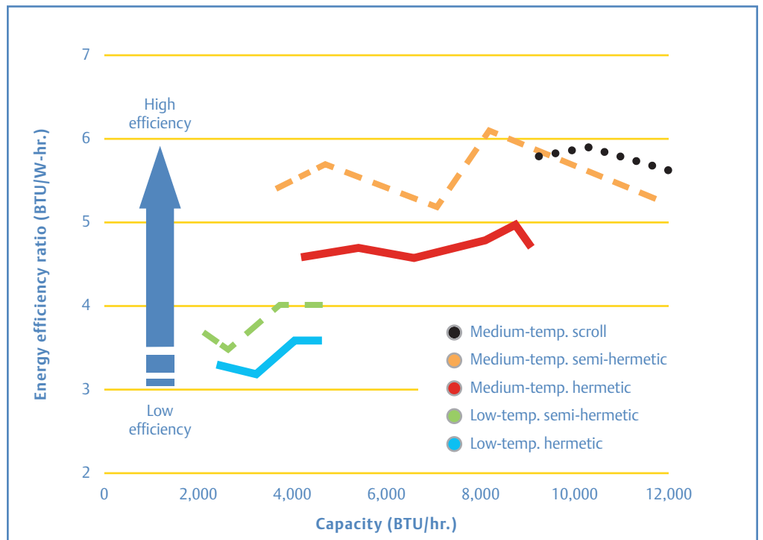
Sources of Energy Consumption

One of largest consumers of energy within reach-in refrigerators and freezers is the compressor. Depending on the unit design, the compressor may be responsible for 35 to 60 percent of the unit's total energy consumption. There are several styles of compressor available, including hermetic (welded), semi-hermetic and scroll. Generally, semi-hermetic compressors consume less energy than their hermetic equivalents, and as a result have a higher (and better) Energy Efficiency Ratio (EER – see Figure 10). Scroll compressors typically are even more energy efficient than semi-hermetic compressors, but are not yet available in the sizes typically required in smaller reach-in refrigerators and freezers.

Figure 10

Compressor Type vs. EER



A second substantial consumer of energy in reach-in refrigerators and freezers is the evaporator and condenser fan motors. In this component category, Permanent Split Capacitor (PSC) motors are generally more efficient than their shaded-pole counterparts. More energy efficient than both PSC and shaded-pole motors are solid-state and electronic-commutated motors, which include Brushless Permanent Magnet (BPM) motors.

The remainder of energy consumption in commercial refrigerators and freezers is by anti-sweat heaters, condensate evaporators, lighting, anti-fog heaters on glass-door models and evaporator defrost systems in freezers. For each of these components, highly energy-efficient design options are available. Additionally, the total energy consumption of several of these components can be minimized by use of an intelligent system controller.

In conclusion, energy-efficiency standards for commercial reach-in refrigerators and freezers are now legislated in several states. Through a coordinated effort, the manufacturers of these products proposed a national standard of energy efficiency, with a proposed effective date of January 2010. This proposal was adopted by the federal government and signed into law in 2005. The national standard is consistent with the originally suggested EPA Energy Star level of energy consumption released in 2001. Individual states have also released legislation that will limit the energy consumption of commercial ice-cream freezers, vending machines, ice machines and walk-in refrigerators and freezers over the next several years.
A similar effort to nationalize these standards is expected. Manufacturers of all commercial refrigeration equipment must be aware of these standards and must prepare their products to meet these increasingly more stringent standards.

Executive Summary

The production, acquisition and use of energy in the United States have become frequently discussed topics with environmental, social, political and economic implications. A substantial amount of energy is used each year to power commercial refrigeration equipment in restaurants, grocery stores, convenience stores and fast-food establishments.
The U.S. Environmental Protection Agency (EPA) released the first voluntary energy-consumption standard for commercial refrigerators and freezers in 2001 under its Energy Star program. Several states, led by California, have since released legislation mandating maximum energy consumption, with effective dates from March 2003 through January 2008. Typically, these standards are less stringent than Energy Star requirements, but over time, they achieve the Energy Star recommended limits.
The states are also releasing similar legislation to limit the allowable energy consumption of commercial ice-cream freezers, vending machines, ice machines and walk-in refrigerators and freezers. In 2005 the Air-Conditioning and Refrigeration Institute (ARI) released a proposal to the federal government to nationalize energy-consumption standards for commercial refrigerators and freezers. The effective date in this proposal was recommended to be January 2010, with the final energy-consumption standards equal to both the original Energy Star proposals and the final California standards. In August 2005 President Bush signed the Energy Policy Act of 2005, which adopted these recommendations. Figure 1 summarizes the effective dates of these energy-consumption limits, as well as the test methods used for determining the energy consumption.

Manufacturers of all commercial refrigeration equipment must be aware of these standards and must prepare their products to meet these increasingly more stringent standards.

Figure 1

Effective Dates of Energy-Consumption Standards

Program	Solid-door reach-in	Glass-door reach-in	Walk-in	Ice machine
EPA Energy Star (fall 2001)	2001 (voluntary)	N/A	N/A	N/A
California Energy Commission (CEC) (August 2003)	2003–2004	2003–2004	N/A	N/A
California Energy Commission (CEC) (April 2005)	2006–2007	2006–2007	2006	2008
Energy Policy Act of 2005	2010	2010	N/A	N/A
Test procedure	ASHRAE 117	ASHRAE 117	Component selection	ARI 810

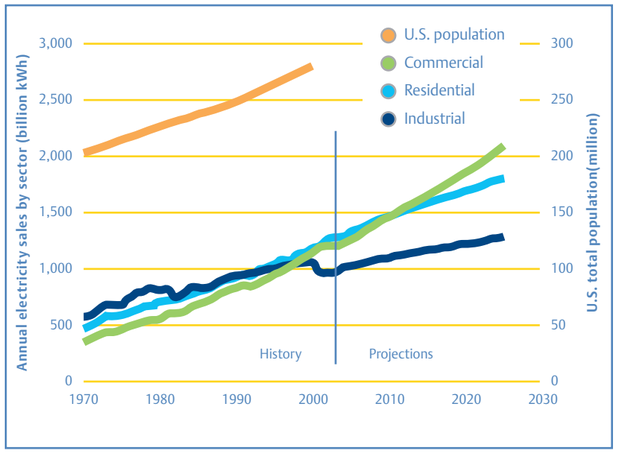
Energy Legislation for Refrigeration Equipment

The production, acquisition and use of energy in the United States have become frequently discussed topics, with a wide spectrum of environmental, social, political and economic implications. One subset of these discussions is the increasing demand for electricity. This paper discusses the consumption of electricity by refrigeration equipment primarily in foodservice industries, the current status of regulation of this consumption and technologies available to reduce the demand for this increasingly limited resource.

From 1970 to 2000, annual electricity consumption by the commercial sector in the United States grew by 229 percent[1], while the total U.S. population grew by 38 percent[2] (see Figure 2). Electricity consumed by the commercial sector surpassed the electricity consumed by industry in the late 1990s, and commercial electricity consumption is forecasted to surpass residential consumption within the next decade. This massive demand for electricity and the byproducts of producing enough electricity to meet these growing demands have been linked to a wealth of social and economic problems, including air, ground and water pollution, direct health issues, national security, the depletion of the ozone layer and global warming.

Figure 2

Electricity Sales and U.S. Population



A substantial amount of energy is used each year to keep food cold or frozen in commercial establishments, including restaurants, grocery stores, convenience stores and fast-food restaurants. The foodservice industry has the highest rate of energy consumption per square foot, due to the need for specialized, high-energy-consuming equipment[3], including commercial refrigerators and freezers. Inside restaurants, refrigeration accounts for 10 to 16 percent of energy consumption[4], and inside supermarkets, refrigeration accounts for 44 to 62 percent[5]. It has been reported that 43 trillion BTUs (12.6 billion kWhs) of total energy are consumed annually by refrigeration inside foodservice buildings[6]. This high rate of electricity use in the previously unregulated commercial refrigeration equipment industry has led several special-interest groups to begin creating new regulations.

The first group in the United States to issue energy regulations for commercial refrigeration equipment was the Environmental Protection Agency (EPA), with its release of Energy Star standards for commercial refrigerators and freezers. Energy Star has become a well-recognized standard, typically seen in residential refrigerators and freezers, washers and driers, and even light bulbs and other energy-consuming products. Anyone who has purchased a "white good" in the last decade is likely familiar with the yellow Energy Star label detailing the expected annual cost of energy required to operate the appliance. Typically, the lower the annual energy consumption and associated cost of operating the appliance, the higher the purchase price of the appliance.

In the fall of 2001, the EPA released its first set of Energy Star guidelines for commercial refrigerators and freezers[7] (see Figure 3). These guidelines were only recommendations for commercial original equipment manufacturers (OEMs) to follow. The guidelines established a maximum daily energy consumption allowed per cubic foot of refrigerated space, for the refrigerator or freezer to be considered Energy Star. These guidelines more manageable, limiting the increase in costs OEMs would ultimately be passing on to consumers. On April 5, 2005, ARI formally recommended to Congress energy-consumption guidelines equivalent to the most stringent California Energy Commission standards (and also the original Energy Star guidelines), with a proposed effective date of January 1, 2010[11]. According to the American Council for an Energy-Efficient Economy (ACEEE), if enacted, this standard would reduce U.S. electricity use by about 2.3 billion kWh annually by 2020 and save consumers and businesses more than $1 billion from products purchased through 2030.

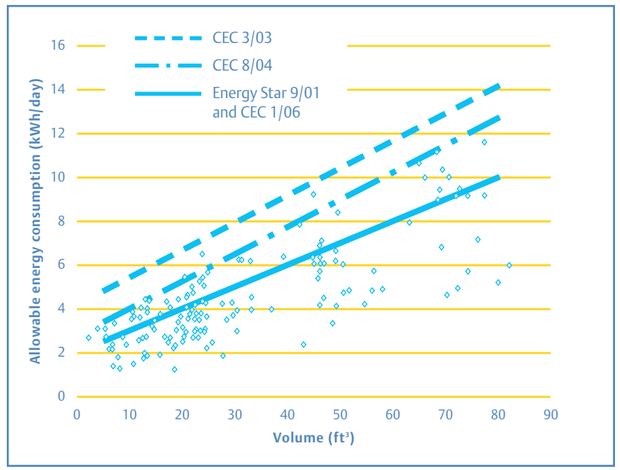
On August 8, 2005, President Bush signed into law the Energy Policy Act of 2005, which included the ARI and ACEEE recommendations for reach-in refrigerator and freezer energy-consumption limits discussed above, as well as increasingly stringent standards for air conditioners and other equipment. According to ARI, "The efficiency levels contained in the law will reduce peak power needs by an estimated 8,000 megawatts by 2020, which is equivalent to the output of 27 new power plants of 300 MW each[12]."

Taking a sample size of 25-cubic-foot units, Figure 9 shows the energy reduction over time imposed by the California Energy Commission. The ultimate result of these standards, combined with the Energy Policy Act of 2005, will be that the original Energy Star recommended levels will be legally mandated nationally at the beginning of 2010. It is anticipated that similar recommendations will be made by ARI and adopted by the federal government in the future regarding national ice-machine standards.

[1]Energy Information Administration, eia.doe.gov
[2]U.S. Census Bureau, www.census.gov
[3]Energy Information Administration, 1995 Commercial Building Energy Consumption Survey
[4]Platts Research & Consulting, Managing Energy Costs in Restaurants, 2002
[5]Platts Research & Consulting, Managing Energy Costs in Grocery Stores, 2002
[6]Waste Reduction Resource Center, wrrc.p2pays.org
[7]ENERGY STAR Program Requirements for Commercial Solid Door Refrigerators and Freezers, energystar.gov
[11]Consensus Agreement on Commercial Refrigeration Efficiency Standards Reached, April 5, 2005
[12]ari.org

Figure 8

CEC-Listed Solid-Door Refrigerators



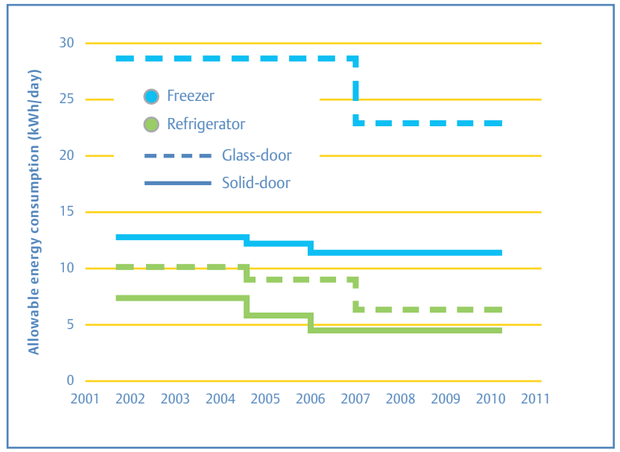
its website of all submitted data. Figure 8 shows all commercial solid-door refrigerators submitted from January 2000 through January 2005. As the figure reveals, many units currently pass the most stringent standard; however, there is also a group of units that passes the August 2004 standard but fails the January 2006 standard. These units will need to be improved and certified in order to be legally sold in California in 2006.

Once California released standards limiting the sale of non-energy-efficient commercial refrigerators and freezers, other states started releasing similar legislation. Maryland, Connecticut and Arizona each enacted legislation limiting the sale of non-energy-efficient commercial refrigerators and freezers. Legislation is proposed or pending in several other states, including Massachusetts, Oregon, Rhode Island, New York and New Jersey, and is expected soon in several more states. Most proposals closely follow the released California standards, although no other states to date have released as comprehensive a program as California. A dissenting opinion was provided by Colorado, where the governor vetoed a bill proposing similar standards. Reasons given for this veto include the expected effect of market forces and the expectation and appropriateness of federal standards instead of state standards.

In 2005 ARI released a proposal to the federal government to nationalize energy-consumption standards for commercial refrigerators and freezers. According to its website, ARI is "the national trade association representing manufacturers of more than 90 percent of North American-produced central air-conditioning and commercial refrigeration equipment[10]." The manufacturers of these products feared that each state would have its own standard and own test-data submittal and approval process. This would result in mountains of paperwork and increased costs for the OEMs. A national standard, however, would only require a single submittal and would be much

Figure 9

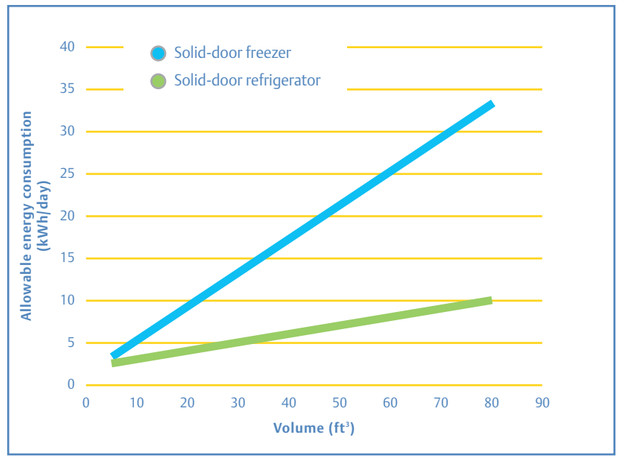
CEC Standards for All 25 ft³ Units



[10]ari.org

Figure 3

Energy Star Consumption Limits



were intended to separate the 25 percent of the marketplace that is the most energy efficient; however, no national legislation was put in place to prohibit the sale of non-Energy Star-rated commercial refrigerators and freezers. Rather, it was expected that the buying public would naturally move to more efficient Energy Star-labeled equipment. If the equipment met the Energy Star guideline, and if the OEM joined the EPA Partnership Program, then the units would be allowed to carry the familiar Energy Star logo. The effective date of the EPA's Energy Star program was September 1, 2001.

According to the Energy Star website, "Replacing all existing commercial solid-door refrigerators and freezers in the U.S. with Energy Star-labeled models would result in savings of almost $250 million per year, or roughly 25 percent of the energy consumed by models currently on the market – the equivalent of eliminating the emissions from 475,000 cars[8]." A list of more than 900 commercial refrigerators and freezers that meet Energy Star guidelines is maintained on the Energy Star website.

This first voluntary standard was important for two reasons. First, it established energy consumption as an important criterion in the buying decision. Typically, the decision-makers buying commercial refrigeration equipment were not concerned with the consumption of energy. At a minimum, energy consumption was low on the list of important considerations, falling behind factors like food safety, uptime (reliability), first costs and serviceability.

The second reason Energy Star was important to commercial refrigeration applications was because it established the first test guideline for determining daily energy consumption. A standard by the American Society of Heating, Refrigerating & Air Conditioning Engineers (ASHRAE), ASHRAE 117-1992, was established as the methodology for determining daily energy consumption. In this test a refrigerator or freezer is loaded with simulated product, and the control is adjusted to maintain a typical set point (0°F±2°F for freezers, 38°F±2°F for refrigerators). Many refrigeration-system temperatures are monitored, as are specific simulated loads. The ambient around the unit is maintained at 75°F. After the unit achieves a steady-state condition, each door is opened for six seconds every 10 minutes for eight hours. This simulates the activity of a refrigerator during its peak use hours. After eight hours, the doors remain closed for the next 16 hours. The total energy consumed during the eight-hour door-opening period plus the total energy consumed during the 16-hour door-closed period is the total daily energy consumption. This same standard has since been used by several other bodies seeking to limit energy consumption on commercial refrigerators and freezers.

One limit of the Energy Star program was that it did not prohibit the sale of non-energy-efficient equipment. Rather, Energy Star provided consumers with decision-making information such that market dynamics would effectively become the governing body.

A second limit of the Energy Star program was that it only covered solid-door commercial refrigerators and freezers. Excluded from the program were all self-contained glass-door commercial refrigerators and freezers, which by their nature consume more energy, although they are less popular in the marketplace than solid-door units.

[8]energystar.gov

California addressed both these shortcomings with its first release of commercial refrigerator and freezer standards. The California Energy Commission (CEC) released an update to its standard, titled *Appliance Efficiency Regulations*, in August 2003[9]. This updated standard addressed the energy consumption of 20 categories of products, ranging from air conditioners to illuminated exit signs. Included in this list for the first time were commercial refrigerators and freezers, with both solid and glass doors. Energy-consumption standards were established for each type of unit, with the maximum allowable energy consumption being reduced over time. The effective date of the first consumption standard was March 1, 2003. The more stringent second standard became effective August 1, 2004 (see Figure 4). As of these dates, any units not specifically listed by the CEC as having been proven through testing to consume less than the allowable energy could not be legally sold in the state of California.

Figure 4

Energy Star and CEC Consumption Limits

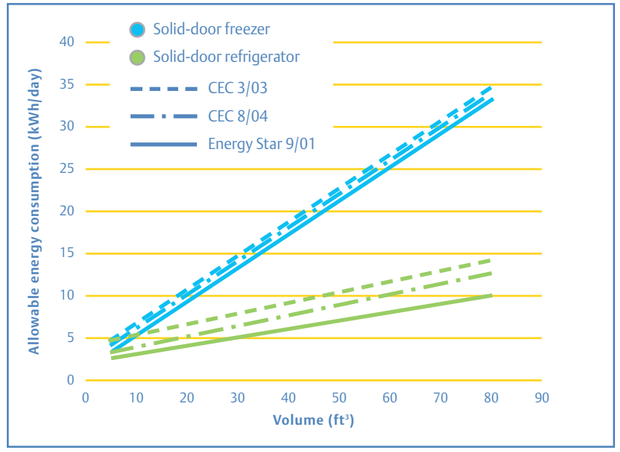
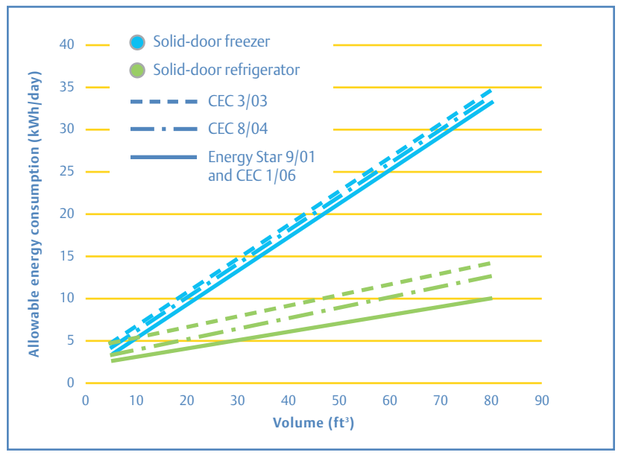


Figure 5

Energy Star and CEC Consumption Limits



This was the first legislative attempt to limit the sale of non-energy-efficient commercial refrigerators and freezers. The new standard included for the first time guidelines for glass- as well as solid-door models; however, the standards set for allowable energy consumption were less stringent than those previously recommended by Energy Star. The March 2003 standard allowed 40 to 90 percent more energy consumption for commercial refrigerators than the voluntary Energy Star guideline, while the August 2004 standard only allowed 27 to 33 percent more. For commercial freezers the March 2003 standard allowed four to 40 percent more consumption than the Energy Star recommended limit; the August 2004 standard reduced it to two to 26 percent more. California also followed Energy Star by using the same criteria for judging daily energy consumption, ASHRAE 117-1992.

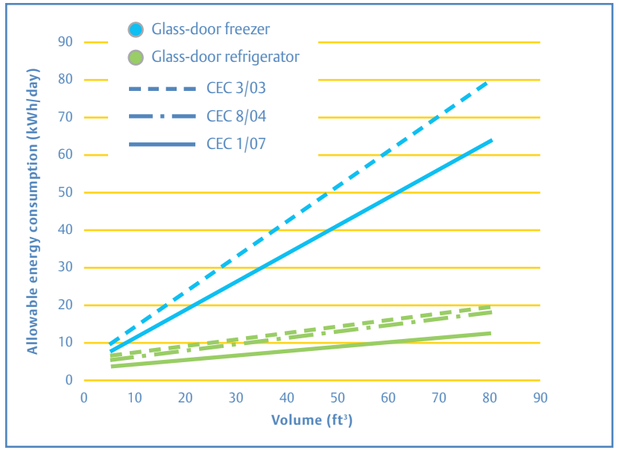
In April 2005 the California Energy Commission released a revised version of its Appliance Efficiency Regulations, covering more product categories and more discreet products per category. Two new tiers of energy consumption for commercial refrigerators and freezers were introduced with this release, each with decreasing allowances for energy consumption. The new CEC standard as of January 2006 ultimately achieves the original voluntary standard set by Energy Star in 2001 for commercial solid-door refrigerators and freezers (see Figure 5).

The January 2007 CEC standard also reduces the allowable energy consumption on glass-door refrigerators by 33 to 40 percent and glass-door freezers by 20 percent from the March 2003 levels (see Figure 6). New standards specifically for ice-cream freezers, with either solid or glass doors, were introduced in this release as well, with an effective date of January 2007. Specific vending-machine energy-consumption standards were also introduced in this revision, with an effective date of January 2006. The formulas to calculate the allowable energy consumption for vending machines are based on a unit's rated capacity to store 12-ounce cans.

The April 2005 CEC guidelines also introduced for the first time energy-consumption standards for ice machines (see Figure 7). These standards go into effect in January 2008 and cover self-contained units as well as ice-making heads and remote condenser models.

Figure 6

CEC Glass-Door Consumption Limits

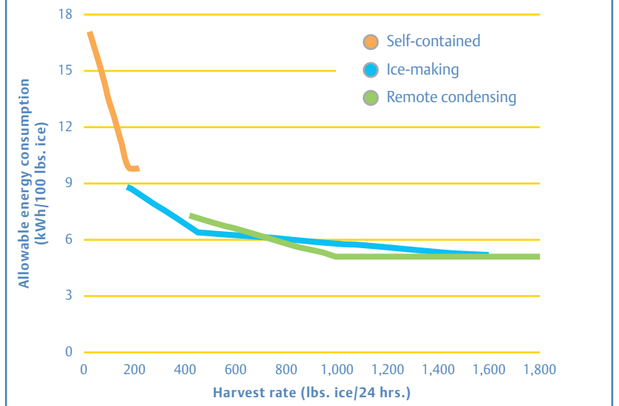


Walk-in refrigerators and freezers were also addressed for the first time in the April 2005 release of the updated CEC standards. For walk-ins, explicit energy-consumption limits were not given; instead, design guidelines were outlined for the construction of these rooms, effective January 2006. These guidelines included mandates that all walk-ins utilize automatic door openers, high-efficiency wall insulation and high-efficiency evaporator and condenser fan motors. Additionally, walk-ins with glass doors must use triple-pane glass doors and must control or limit the total power used by anti-sweat heaters.

In order to sell commercial refrigerators or freezers in California, a production sample of the model must be tested by a CEC-certified test laboratory, with resulting data submitted to and approved by the CEC. The California Energy Commission maintains records on

Figure 7

Ice-Machine CEC Standards



[9]energy.ca.gov