DOE Regulations Drive Significant Energy Reductions

Compressed timetable for regulatory compliance puts pressure on equipment supply chain


Potatoes

Coming off of a year defined by increased environmental regulations in the U.S., the commercial refrigeration equipment supply chain is facing a big challenge in 2015—preparing for compliance. While the Department of Energy (DOE) has mandated significant reductions in energy consumption by 2017, the Environmental Protection Agency (EPA) is calling for the phase-out of commonly used refrigerants by 2016. Achieving compliance will not only require a precise understanding of the regulations, but also an accelerated development process to prepare for the new standards.

Individually, each regulation represents substantial long- and short-term impacts to system design. Collectively, these stricter rules create a perfect regulatory storm that demands the immediate attention of original equipment manufacturers (OEMs) as well as the complete refrigeration equipment supply chain. The product classes most affected by the new DOE rule include self-contained, reach-in refrigerators, walk-in coolers and freezers, and ice machines. With 2017 just around the corner, the race is on to design, test and certify equipment for compliance.

An ongoing regulatory evolution

Regulations in the commercial refrigeration space are nothing new. In 2001, the EPA introduced its ENERGY STAR program to establish voluntary energy consumption guidelines for commercial refrigerators and freezers. These guidelines were then adopted as state law by the California Energy Commission (CEC), outlawing the sale of non-conforming products. Subsequently, the Air-Conditioning and Refrigeration Institute (ARI) took a proactive energy reduction stance by recommending standards to Congress that were equal to the most stringent of those proposed in California. The resultant Energy Policy Act of 2005 became the national law in 2010.

Since the Montreal Protocol in 1989, the refrigeration and air conditioning industries have been under ever tightening regulations on the use of refrigerants. While the Montreal Protocol and amendments to the Clean Air Act were enacted to phase down the use of ozone depleting CFC- and HCFC-based refrigerants such as R-22, the EPA has since expanded this initiative to also limit the use of refrigerants with high global warming potential (GWP) such as R404A.

Continuing along this evolutionary line, both regulatory bodies recently introduced updated regulations that again target commercial refrigeration equipment used in food retail. The DOE published a final rule in 2014 that outlined the significant reductions in energy consumption that must take place by 2017. Per equipment class, these reductions are outlined in Figure 2.

As a result, the equipment supply

FAST ENERGY FACTS

- From 1980 to 2010, annual electricity consumption by the commercial sector in the United States grew by nearly 250 percent, while the total U.S. population grew by 39 percent.
- 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, including commercial refrigerators and freezers.
- Restaurant refrigeration accounts for 10 to 16 percent of energy consumption.
- Supermarket refrigeration accounts for 44 to 62 percent of energy consumption.
- 43 trillion British thermal units (Btu) — or 12.6 billion kilowatt-hours (kWh) — of total energy are consumed annually by refrigeration inside foodservice buildings.

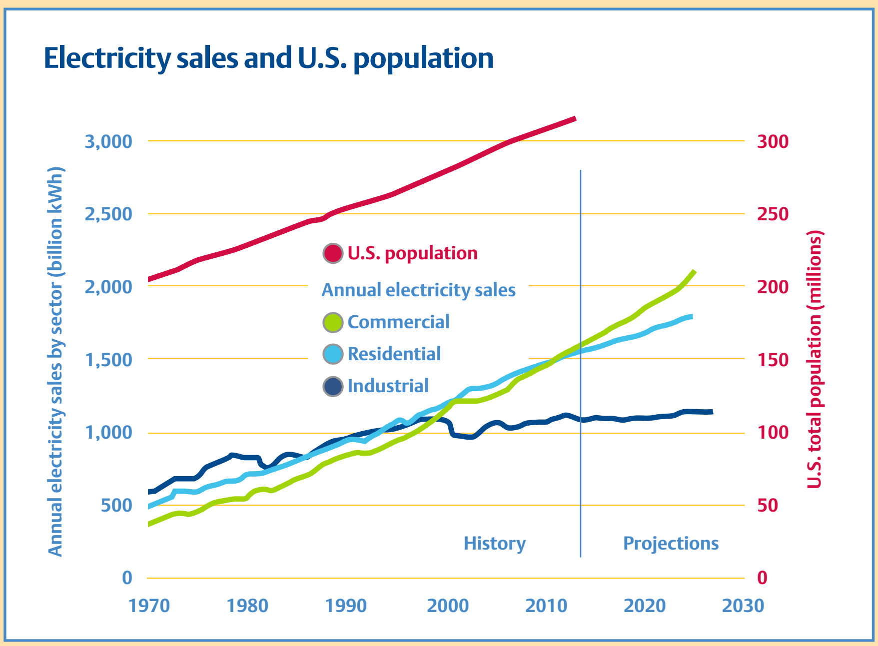


Figure 1: Commercial sector (green line) is the highest consumer of electricity in the U.S.

chain began in earnest the process of designing, testing and certification of new reach-ins, walk-ins and ice makers.

Later in 2014, the EPA also introduced its significant new alternatives policy (SNAP) and subsequent notice of proposed rulemaking (NOPR) that recommends the delisting of many commonly used refrigerants by 2016. In particular, R404A and R507A were identified for potential phasing out due to their perceived higher GWP. But since SNAP was introduced after the DOE's final rule, these refrigerants were used in the certification of many of the preliminary refrigeration system architectures designed to achieve the lower energy consumption levels in the 2017 rule.

Industry stakeholders across the nation have submitted numerous data-backed comments into the Federal Register in response to the NOPR urging an extension in the time frame to delist R404A and R507A. The EPA is currently considering these comments and is expected to issue a final rule early this year. In the meantime, the equipment supply chain must continue the process of meeting DOE energy compliance despite the refrigerant dilemma. The good news is that there are several viable refrigerant alternatives, although they will present new design challenges, safe handling requirements, and performance and efficiency implications.

Strategies for achieving DOE compliance by 2017

Prior to the DOE's final rule in 2014, OEMs had been able to achieve the required incremental reductions in energy consumption by addressing the issue at the component level. To achieve compliance with the currently proposed double-digit reductions in energy consumption, OEMs will need to evaluate efficiencies holistically, considering each component as well as the overall efficiency of the system design and architecture.

Achieving compliance will not only require a precise understanding of the regulations, but also an accelerated development process to prepare for the new standards.

Selecting the most energy-efficient components that make up the refrigeration subsystem is a good start toward meeting energy-use regulations. For example, the compressor can be responsible for up to 60 percent of a system's total energy use. Evaporator and condenser fan motors are the second-highest energy consumers. Variable capacity scroll compressors and electronic commutated motors (ECM) are the most efficient compressor and fan motor options available to OEMs today.

Per the DOE's technical support documentation, there are many design options that are available to help meet 2017 efficiency levels. Recognizing that there will undoubtedly be cost adders for the proposed design options, the DOE has also estimated the amount of time it will take for the energy efficiency gains to generate a return on investment.

Let's take a look at the 2017 rule as it applies to each refrigeration equipment class.

Reach-ins — The DOE is requiring a 30–50 percent energy reduction measured in kilowatt hours per day (kWh/day) by March 2017. Because of the wide variety of self-contained, reach-in refrigerators in use, the DOE has proposed a multitude of design options to help lower energy usage across the class (see Figure 3). Please note that the DOE has provided efficiency equations for each specific type of reach-in unit to help OEMs calculate overall product energy usage.

While every design option listed in Figure 3 will help achieve the energy efficiency levels needed to comply with the DOE's regulations, not all will necessarily make sense for every product in the reach-in class. For example, increasing

Status of DOE Energy Regulations

Product Class	Current	NOPR	Final	Effective	Energy Level Reduction
Reach-ins (Self-contained)	2010	Oct. 2013	March 2014*	March 2017	kWh/Day 30% – 50%
Ice Makers	2010	March 2014* / NODA Sept. 2014	January 2015	January 2018	kWh/100 lbs 5% – 15%
Walk-ins	2009	Sept. 2013	June 2014*	June 2017	AWEF 20% – 40%

*Industry challenging DOE ruling.

Figure 2: DOE proposes significant energy reductions compared to current standards.

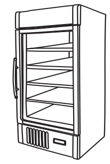
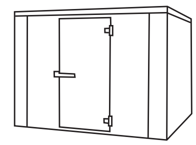
DOE Recommended Design Options and Operational Strategies to Reduce Energy Consumption	 **Reach-ins**	 **Walk-ins**	 **Ice Machines**
Higher efficiency compressors	X	X	X
Variable speed compressors	X	X	X
Higher efficiency condenser fan motors (ECM)	X	X	X
Higher efficiency evaporator fan motors (ECM)	X	X	
Variable speed evaporator fans		X	
Variable speed condenser fans		X	
Modulated evaporator fan		X	
Improved condenser fan blades	X	X	
Improved evaporator fan blades	X	X	
Improved condenser coil design (larger coils)	X	X	
Thicker case insulation and improved doors	X		X
Non-electric antisweat/defrost	X		
Night curtains (for equipment without doors)	X		
Float heading pressure		X	
Floating head pressure with EXV		X	
Hot gas defrost		X	
Ambient sub-cooling		X	
Reduced evaporator thermal cycling			X
Reduced meltage during harvest			X

Figure 3: Here are some of the key strategies the DOE has identified to reduce energy by 2017–2018.

For a more comprehensive list and application-specific recommendations, please see the following:
REACH-INS http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0003-0102
WALK-INS http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0015-0131
ICE MACHINES http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0037-0061

the size of condenser coils is one option OEMs may leave off the table to reduce energy consumption, because it may compromise the end user's demand for a small footprint in a market where every square foot counts. It does, however, achieve needed efficiencies without being as significant of a cost adder. Ultimately, the market will determine if this trade-off between cost and footprint is favorable.

Walk-ins — The DOE is requiring a 20 – 40 percent energy reduction measured in annualized walk-in energy factor (AWEF) calculations. They have divided walk-in application and architecture according to the condensing method used—dedicated or multiplex condensing.

Dedicated condensing (DC) is the practice of having a single, dedicated condensing unit that supplies cooling to a single walk-in unit, whether they are integrated into a single packaged system or housed in separate sections. The condensing unit can be located indoors or outdoors. *Multiplex condensing* (MC) refers to a single condensing unit rack system that supplies cooling for multiple walk-in coolers and freezers.

To determine system efficiency, the DOE uses a classification system that describes the type of condensing unit architecture, its location, the type of compressor used, and its capacity. This data can then be used along with R-values of insulation panels and lighting/sensors as the three primary variables of the AWEF calculations. Please see the walk-ins category in Figure 3 to review the DOE's recommendations to achieve compliance with the 2017–2018 rules.

Ice machines — Energy efficiency in ice machines is measured in kWh per 100 pounds of ice produced. The DOE rule on ice machines is expected to be finalized in early 2015. Initially introduced in March 2014, it proposed a 15 – 25 percent reduction in energy by 2015. But, due to an abundance of industry commentary into the Federal Register, it has since been amended to 5 – 15 percent with a deadline tentatively set for January 2018.

Ice machines are designed for one of two operational cycles: batch and continuous. Recommended design options for OEMs preparing for the final rule are listed in Figure 3.

For continuous ice machines, OEMs

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face a smaller efficiency hurdle than for batch machines. Because batch machines have a harvest cycle to contend with, achieving the required efficiencies is more difficult than a continuous production cycle.

Bottom line: compliance comes with a cost

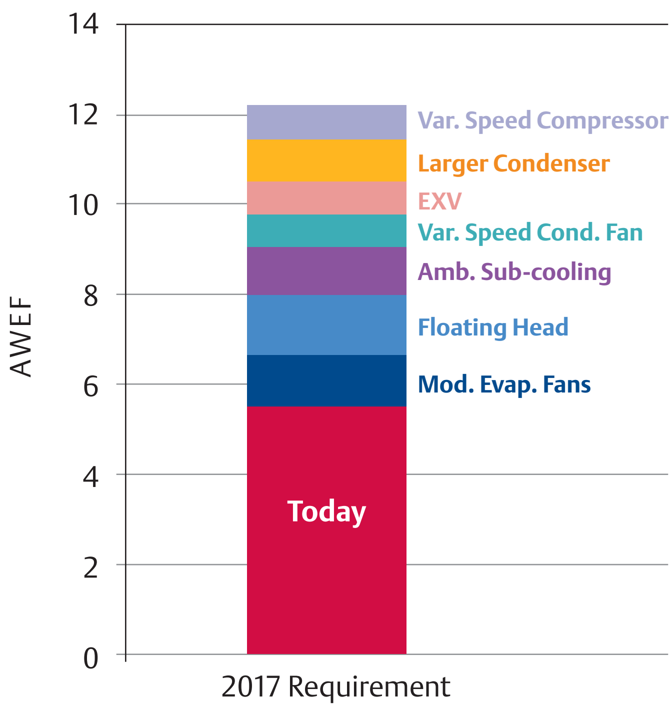
To meet the DOE's regulations for reach-ins, walk-ins and ice machines by 2017, it will require tremendous effort and coordination across the commercial refrigeration equipment supply chain. But, it can be done. With refrigeration system architectures affected on this order of magnitude and the compressed time frame for implementation, something has to give. Unfortunately, this means an increase in equipment costs.

Take walk-ins, for example. The DOE has estimated the costs to achieve 2017 compliance using AWEF calculations. Starting with the baseline cost of $5,383 for a walk-in unit, the DOE then adds the component and system changes needed to comply and estimates the costs. In this case, it's a 47 percent increase in unit cost to $7,889. This, of course, will not be an easy sell to the end user. But, the DOE also estimates the annualized savings these efficiency upgrades will net. With baseline energy costs estimated at $3,479, the DOE projects a reduction in energy costs of 53 percent, down to $1,637 per year (see Figure 4).

Whether these calculations prove to be accurate or not remains to be seen. What is certain is what matters to our end users. And at this time, maintaining product quality, low first costs and energy efficiency are equally important.

The challenge to the commercial refrigeration supply chain is to balance the regulatory requirements with the demands of the marketplace. It's inevitable that first costs are going to rise to achieve reduced energy consumption, but the promise of long-term efficiency savings may help ease the pain for the end user.

DOE Annualized Walk-in Energy Factor



Cost vs. Energy Savings

Design Option	Price	Annual Savings
Baseline	$5,383 base price	$3,497 base energy cost
Modulated Evap Fans	+$67	–$247
Variable Speed Evap Fans	+68	–$185
Floating Head Pressure	+$40	–$340
Ambient Sub-cooling	+$135	–$221
ECM Cond Fan Motor	+$50	–$59
Variable Speed Cond Fans	+$67	–$74
Larger Cond Coil	+475	–$359
EXV	+$203	–$109
Enhanced Evap Fan Blades	+$111	–$18
Variable Speed Compressor	+$1,265	–$245
Enhanced Cond Fan Blades	+$25	–$3
	$7,889 (+47% price)	**$1,637** (53% savings)

Figure 4: End users will have to look for energy savings to offset rising first costs.