INTEGRATION OF DEMAND RESPONSE INTO TITLE 20 FOR OPEN AND CLOSED REFRIGERATED DISPLAY CASES

Phase1: Demand Response Potential

DR 09.05.01 Report

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What's Inside...

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Disclaimer

ABBREVIATIONS AND ACRONYMS

ASH	Anti-sweat Heaters
CEUS	Commercial End Use Survey
DOE	US Department of Energy
DR	Demand Response
EE	Energy Efficiency
PG&E	Pacific Gas & Electric
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
SMUD	Sacramento Municipal Utility District
TDA	Total Display Area

EXECUTIVE SUMMARY

This project seeks to validate and estimate the Demand Response (DR) potential for refrigerated display cases in the California Appliance Efficiency Standards (Title 20).

A short-term study was conducted to estimate the total DR potential of refrigerated display cases in SCE service territory. This included an estimation of the population of display cases, contemplation of market acceptance factors, an exploration of potential DR strategies, and a determination of system-wide DR potential for each strategy.

Using projections from a recent Department of Energy energy efficiency rulemaking, the total demand of refrigerated display cases in a medium sized supermarket (45,000 ft^2) was estimated to be 142 kW. Three DR strategies were investigated: case temperature reset, lighting reduction, and day-ahead temperature pull-down. The lighting measure is fairly straightforward and can achieve a 21,000 kW reduction with 10% market adoption. There are some concerns with effects on merchandising when lights are turned off, but these could probably be overcome with minimal efforts.

For the temperature reset and pull-down strategies, there are serious concerns about applicability to different types of equipment, food safety issues, and impact on customer economics. For example, medium temperature display cases will most likely not be included in such a strategy because of their inherent vulnerability to food spoilage. The most likely candidate for these strategies is low temperature display cases with transparent doors. Initial estimations suggest a 35,000 kW DR potential at 10% market acceptance for this class. However, the methodology employed here does not account for the duration of the DR period and may significantly overstate actual savings. More data on the temperature characteristics of display cases undergoing DR events is needed before a more accurate estimation of DR potential can be determined.

It is recommended that the DR strategy for display case lighting start immediately. There are major efforts currently underway to transform display case lighting from an energy efficiency perspective through new technologies such as LED. Incorporating DR into new installations that are planned to occur very shortly can provide more refined information on DR potential of this strategy.

The temperature reset and day ahead pull-down strategies need to be investigated more thoroughly before they can be incorporated into code. The impacts of DR on display case performance must be studied in a laboratory environment before implementation, rather than in the field, because of the potential problems associated with food safety. Once this performance data is known and there are more accurate estimates, industry participation in this effort will be crucial in order to ensure that a code effort is successful.

INTRODUCTION

This project seeks to validate and establish demand response (DR) potential for open and closed refrigerated display cases. It is part of a multi-phase, multi-year effort to evaluate the potential for DR to be incorporated into the California Appliance Efficiency Regulations (Title 20) for a series of 13 commercial and residential appliance categories from open and closed refrigerated display cases to home office equipment.

This project aligns well with the objectives of Southern California Edison's (SCE) SmartConnect™ by fostering and accelerating the availability of DR-ready appliances in the market place. Furthermore, this project supports the California Public Utilities Commission goal of zero net energy (ZNE) for residential new construction by 2020 and commercial new construction by 2030.

Phase 1 of this potential three phase effort addresses the DR potential for open and closed refrigerated display cases; If Phase 1 yields encouraging results, Phase 2 will demonstrate DR capabilities and strategies for open and closed refrigerated display cases; and if the demonstration is successful, Phase 3 will develop a Title 20 Codes and Standards Enhancement initiative to incorporate DR requirements for open and closed refrigerated display cases.

This report reviews the findings from Phase 1 to estimate the DR potential for open and closed refrigerated display cases. This phase entails assessing the demand reduction associated with open and closed refrigerated display cases, the population statewide and within SCE service territory, and the market/customer acceptability of DR strategies associated with open and closed refrigerated display cases.

TECHNOLOGY DESCRIPTION

Refrigerated display cases are used to merchandise perishable foods and other goods. "Display cases" is a generic term that encompasses numerous subcategories of equipment with varying physical and operational characteristics significantly impacting their energy consumption. The United States Department of Energy's (DOE) 2009 energy efficiency rulemaking divided display cases into 38 different product classes in order to account for differences in energy consumption between these various configurations[1]. The following sections discuss several distinguishing characteristics that impact the feasibility of integrating DR into specific classes of display cases. (See Appendix for a breakdown of all equipment classes.)

OPERATING TEMPERATURE

Display cases are designed to operate within specific temperature ranges based on the type of food they merchandize. Three temperature designations are commonly used to distinguish between the different types of cases: medium temperature (MT), low temperature (LT), and ice cream (IC). Design temperatures and applications are shown in Table 1.

TABLE 1. TEMPERATURE DESIGNATIONS

EQUIPMENT CLASS DESIGNATION	RATING TEMPERATURE	APPLICATION
MT*	38°F	Perishable fresh foods (meat, dairy, deli, and produce)
LT*	0°F	Frozen foods (vegetables, juices, and frozen dinners)
IC*	-15°F	Ice cream

**DOE uses M, L, and I, respectively.*

THERMAL BOUNDARY

The overall construction of a display case's thermal boundary has the greatest influence on its energy consumption. The two basic configurations are open and closed cases.

Open cases are most common in meat, dairy, and deli departments of supermarkets and are constructed such that at least one side of the case is permanently exposed to the surrounding environment. Because of this design open cases entrain warm moist air from the adjacent space. The moisture in the air condenses and freezes on the evaporator coil reducing its heat transfer effectiveness, choking airflow through the coil, and requiring more frequent defrosts to remove the ice build-up. The result is that these cases require up to 80% more cooling energy than similar closed cases.

Closed cases typically have a glass door or similar barrier that creates a full thermal boundary around the refrigerated space. These cases are most common in frozen food aisles of supermarkets and are slowly making their way into beverage and dairy departments. By removing the infiltration load, the cases can reduce the problems associated with frosting of the coil and are able to maintain more constant product temperature and use less energy.

Table 2 lists the different equipment class designations used by DOE to distinguish between basic case construction families.

TABLE 2. DISPLAY CASE FAMILY DESIGNATIONS

EQUIPMENT CLASS DESIGNATION	FAMILY
VOP	Vertical Open
SVO	Semi-vertical Open
HZO	Horizontal Open
VCT	Vertical Transparent Doors
VCS	Vertical Solid Doors
HCT	Horizontal Transparent Doors
HCS	Horizontal Solid Doors
SOC	Service Over Counter

Refrigeration System Configuration

Display case refrigeration systems come in two distinct forms, self-contained and remote. Self-contained display cases contain all refrigeration components, including compressors and condensers in one package; these systems reject heat to the surrounding space. Remote display cases contain only evaporators and evaporator fans, which are connected to a centralized refrigeration system.

A typical supermarket remote system contains several compressor racks, each with multiple compressors that are piped either in a loop or direct circuit to display cases, and walk-in coolers and freezers. The racks accommodate the evaporators by maintaining the lowest suction temperatures for the group. Typically, three to five compressor racks are employed to provide all refrigeration in the supermarket. Each compressor rack may have 3 to 5 compressors serving a series of loads with nearly identical evaporator temperature. In supermarkets the compressors are typically located in a mezzanine at the rear of the store and condensers are on the roof, rejecting heat to the outdoor environment.

Table 3 lists designations for refrigeration system configurations. (DR opportunities for remote refrigeration systems are covered in the DR 09.06.01 report.)

Table 3. Operating Mode Designations

Equipment Class Designation	Operating Mode
RC	Remote Condensing
SC	Self Contained

Display Case Components

Display cases are an assemblage of many individual energy-consuming components working together to perform necessary functions. However, each component may have DR potential independent from the others. The major case components are shown in Figure 1 and their functions are described in the text immediately following the figure.

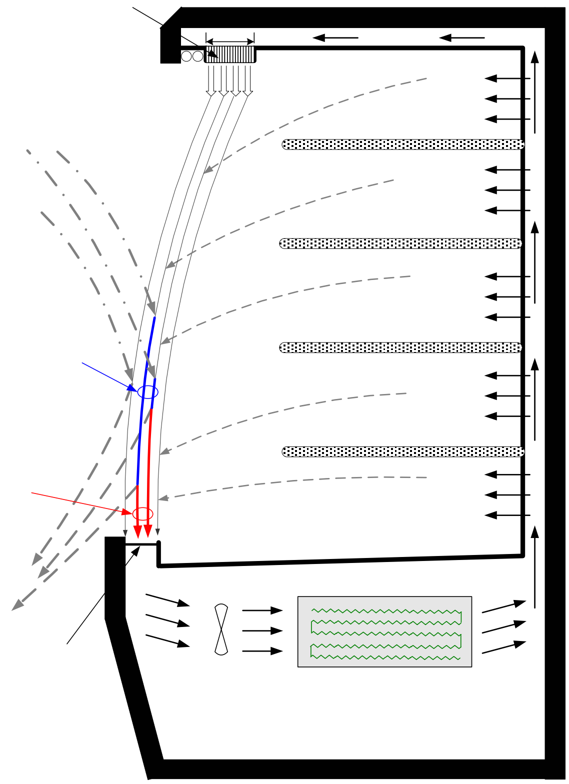

FIGURE 1. SCHEMATIC OF A REMOTE OPEN FRONT VERTICAL DISPLAY CASE

Evaporator Fans – circulate air through the cooling coil (evaporator) into the air distribution plenum and out to the refrigerated space. When fans are turned off, the refrigeration system alone is incapable of cooling the display case.

Lights – illuminate products for merchandising purposes. Typically, cases use T8 fluorescent lamps, but newer efficient technologies such as LED, fiber optic, and cold cathode lighting are now entering the market.

Anti-sweat heaters (closed cases only) – prevent condensation formation on exposed surfaces of closed cases. Typically, Anti-sweat heaters (ASH) are located in the door frames and around the perimeter of glass doors. Condensation on the frames can cause doors of LT cases to freeze shut, which puts door gaskets at risk of being torn. The condensation may also drip off the case and onto the floor, creating slip hazards for customers. Condensation on the inside surfaces of glass doors cause them to fog, obstructing the customer's view of products inside the case. (DR opportunities for ASH are covered in the DR 09.05.02 report.)

Defrost heaters (LT only) – evaporator coils of display cases become frosted during normal operation due to entrainment of warm, moist air from the sales floor. Defrost cycles are typically initiated by a time clock (e.g., four times per day) and terminated either by a time clock (e.g., 45 minutes of defrost) or a temperature sensor (e.g., air leaving the evaporator has reached 42°F).

Compressors – perform mechanical work on a refrigerating fluid to take advantage of its thermodynamic properties and provide cooling to a space. In this report, compressors of both self-contained and remote equipment are considered. (Remote compressors are addressed further in the DR 09.06.01 report.)

Condenser fans – reject the heat absorbed by the refrigerant from the cold space to the ambient environment. Typically, the condenser is air-cooled and requires a fan to blow air across it. In larger remote systems, there may be an evaporatively-cooled cooling tower or other device used to reject heat, but all commonly require some sort of fan. (Remote condensers are addressed in more depth in the DR 09.06.01 report.)

CURRENT ENERGY CODE REQUIREMENTS

The wide variety of components and configurations present in display cases has contributed to them remaining unregulated appliances in the United States. However, in January 2009, the DOE published energy standards for 38 display case equipment classes that apply to cases manufactured on or after January 1, 2012.[2] These energy consumption standards are based on the total refrigerated volume for closed cases with solid doors and the total display area (TDA) for open cases and closed cases with transparent doors. No DR capabilities are included in this standard. Because this report only deals with sales floor units which must be open or have transparent doors for marketing purposes, the solid door cases will be ignored.

There currently are no California Title 20 standards, nor ENERGY STAR® programs addressing display cases.

DEMAND PROFILE AND ENERGY CONSUMPTION

Because of the wide variation in product classes, demand and energy consumption cannot be easily reported as a single value. Figure 2 shows daily energy consumption as a function of Total Display Area (TDA) for 30 display case classes based on the DOE Standards.[3] For a TDA of 60 ft^2, daily energy consumption ranges from 9.73 kWh to 348.02 kWh depending on the type of equipment. This includes compressor and condensing unit consumption for both remote and self-contained equipment.

Assuming that energy is consumed in a consistent pattern over the day, the power demand could range from 272 W to over 9 kW per 40 ft^2 of TDA. For the most prevalent case types (VOP.RC.M, VCT.RC.L, and VCT.RC.I) the range is approximately 1.0 kW to 1.5 kW for the same size TDA, see Figure 3.

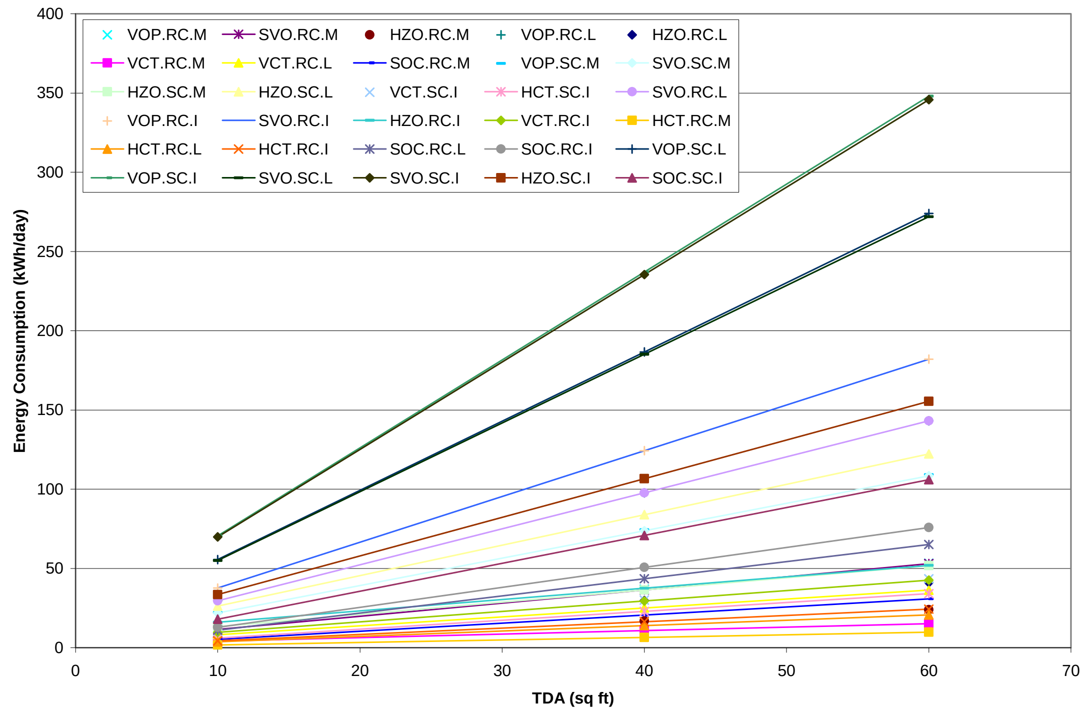

FIGURE 2. DAILY ENERGY CONSUMPTION FOR SEVERAL DISPLAY CASE CLASSES AS A FUNCTION OF TDA

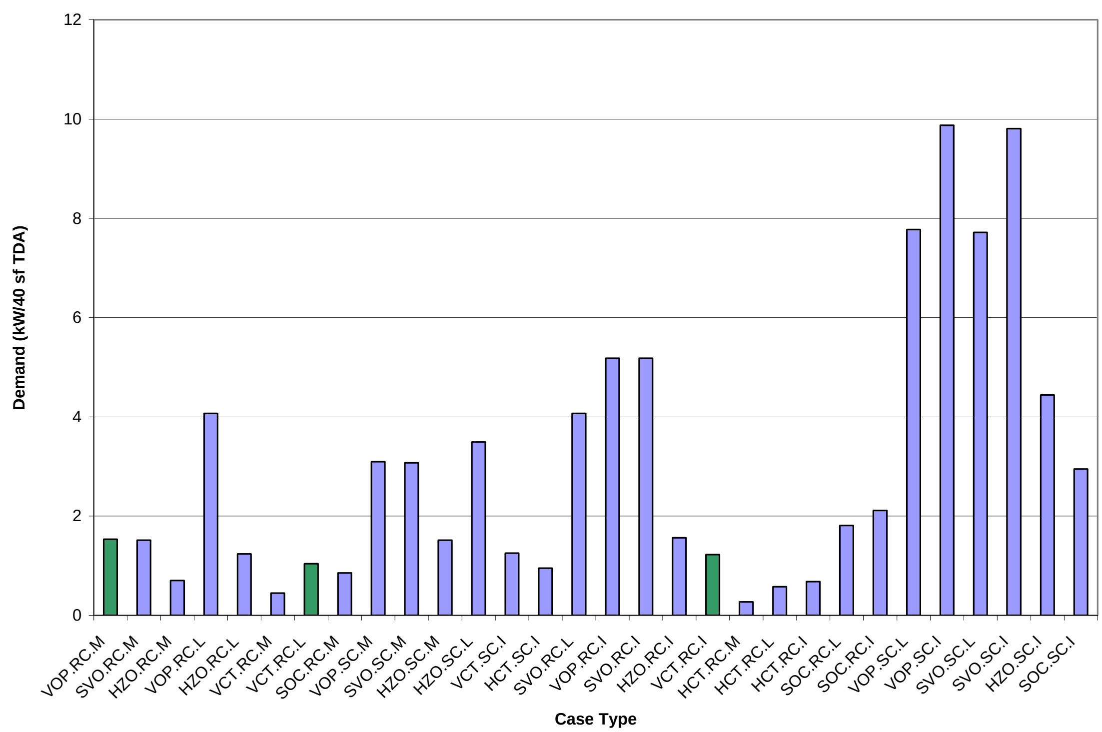

FIGURE 3. DEMAND FOR SEVERAL DISPLAY CASE CLASSES ASSUMING 40 FT^2 OF TDA

MARKET SIZE

To estimate the number of supermarkets and grocery stores in SCE service territory and statewide, the information in the Commercial End-Use Survey (CEUS)[4] report was used.[5] Note that the information in CEUS was only for SCE, Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), and Sacramento Municipal Utility District (SMUD), and it did not include other municipal utilities in California.

While CEUS divided the total number of supermarkets and grocery stores into three main categories according to their annual energy consumption, see Table 4, it did not provide the actual number of stores for each category in the report. Nonetheless, CEUS provided the number of stores in each of the three size categories that was planned to be sampled, which can serve as a proxy for the actual distribution, see Table 4. For example, it was estimated that small size grocery stores comprise of about 27% of the total grocery stores. For medium and large size grocery stores, the distribution was estimated to be about 47% and 26% of the total grocery stores, respectively. There was no correlation between energy consumption and physical footprint size, so additional market research would be necessary to increase the accuracy of DR potential calculations.

TABLE 4. GROCERY STORES SIZE CLASSIFICATION AND DISTRIBUTION ACCORDING TO ANNUAL ENERGY CONSUMPTION

GROCERY STORE SIZE CATEGORIES	ANNUAL ENERGY CONSUMPTION (KWH / YEAR)	AVERAGE DISTRIBUTION (% OF TOTAL)
Small Size	Less than 190,000	27%
Medium Size	Between 190,000 and 1,600,000	47%
Large Size	Greater than 1,600,000	26%

Table 5 summarizes the total number of stores in SCE, PG&E, SDG&E, and SMUD, as well as the number of stores according to their size classification for these service territories. Table 5 also shows the total number of stores for each of the three size classifications that can be used as a proxy for the actual number of stores in the state of California.

TABLE 5. TOTAL MARKET SIZE, AND MARKET SIZE FOR SMALL, MEDIUM, AND LARGE SIZE GROCERY STORES

SERVICE TERRITORY	TOTAL GROCERY STORES	SMALL SIZE (27% OF TOTAL)	MEDIUM SIZE (47% OF TOTAL)	LARGE SIZE (26% OF TOTAL)
SCE	10,760	2,905	5,057	2,798
PG&E	12,293	3,319	5,778	3,196
SDG&E	2,632	711	1,237	684
SMUD	825	223	388	215
Total	**26,510**	**7,158**	**12,460**	**6,893**

A typical supermarket has approximately 60 to 80 display cases. About 60% of these are medium-temperature cases and 40% are low-temperature cases. Most of the medium-temperature cases are open display cases. DOE used the values from Table 6 for a medium size store to estimate energy consumption for a 45,000 ft^2 supermarket. No guidance was provided for smaller or larger stores, so multipliers of 50% and 125%, respectively, of the medium store length were used.

TABLE 6. LINE-UP LENGTH FOR 45,000 FT^2 SUPERMARKET[6]

EQUIPMENT CLASS	UNIT LENGTH (FT)	LINE-UP LENGTH (FT)		
		SMALL*	MEDIUM	LARGE*
VOP.RC.M	12	192	384	480
SVO.RC.M	12	42	84	105
VCT.RC.M	12.7	12.7	25.4	31.8
HZO.RC.M	12	12	24	30
SOC.RC.M	12	12	24	30
VOP.RC.L	12	12	24	30
VCT.RC.L	12.7	133.4	266.7	333.4

*Length for small and large supermarkets based on 50% and 125%, respectively, of medium supermarket length.

MARKET BARRIERS

There are several over-arching factors that will impede acceptance of DR strategies by SCE customers. The concept of DR must be approached differently for these customers due to the critical role of electricity in their operation. While they may be adverse to DR in refrigeration, they must be reminded that without DR, the likelihood for extended, widespread power outages is increased. The losses resulting from such outages will likely far outweigh detrimental impacts of DR implementation. This follows the line of thought used in avoided cost analyses.

FOOD SAFETY

The FDA Food Code requires that all fresh foods be kept at a maximum temperature of 41°F to prevent spoilage and growth of food-borne illnesses. Because most of these fresh foods are maintained at temperatures at approximately 36°-38° F, there is little room for temperature fluctuation that results from shutting down any of the cooling equipment.

The most common DR measures for refrigeration involve turning off refrigeration equipment, which creates the risk of exceeding allowable temperature limits. Furthermore, many of the control systems used in the field today do not operate with tight tolerances, which increase the risk that temperatures will not be maintained properly. Thus, MT cases on the whole are not suitable for DR participation.

There may be an argument that cases holding non-perishable items, such as sodas, beer, sports drinks, and other beverages are capable of withstanding more pronounced temperature fluctuation. However, the inherent danger is that the type of product in a particular case may change over time. There is no way to guarantee that a case holding soda today will not be holding milk and dairy products 6 months from now. Thus, it appears that utilities have the potential of incurring significant liability if MT cases are included in any temperature-changing DR schemes.

LT and IC cases are typically able to withstand moderate changes in temperature because the products merchandised in them are maintained well below the freezing point and are not susceptible to thawing. Thus, DR strategies are more applicable here.

MARKETING IMPACTS

The main purpose of display cases is to merchandize perishable products to consumers. Any DR measures must not interfere with this purpose to the degree that they have a significant impact on the ability of cases to sell product. Historically in supermarkets, marketing aspects of cases have always been more important than energy consumption or thermal performance. For example, open display cases are commonplace in every supermarket today despite the opportunity to save nearly 80% on energy costs by switching to identical cases with doors. The reason is that the merchandisers are concerned that placing a door in between the customer and the product will so drastically cut into sales that any potential savings would be overshadowed by the loss of sales. In addition, any measures that reduce visibility of products to the customer by reducing lighting levels or allowing glass doors to fog more than usual will not be accepted by the market. Therefore, research projects are currently underway to assess the sales impact of adding doors to refrigerated display cases to address the concerns voiced by the grocery industry.

COMPLEXITY

One of the biggest hurdles to overcome in widespread deployment in refrigeration programs for supermarkets is the lack of consistent refrigeration system design, even among stores operated by the same chain. These systems are connected to numerous types of display cases and walk-in coolers and incorporate any number of controllers using different communication protocols. The end result is that no two systems are alike and implementation of any DR strategy can require significant amounts of specialization for individual locations. This will likely increase implementation costs.

COST

The grocery industry operates on very tight profit margins; usually less than 1% of sales, and energy costs typically exceed profits. As such, they require energy efficiency and DR measures to have very short payback periods. Because some of the DR strategies proposed in this report may be very costly to implement in a particular store location, let alone across a chain with many vintages and store configurations, the associated DR rate structure must provide sufficient incentives to meet the payback criteria.

INTRUSION INTO SALES AREA

Like most business owners, grocery store operators are very hesitant to allow work crews in their facilities during operating hours. This is especially true when refrigerated cases are involved because customers who see any type of work undertaken on a case might assume that there is a problem with all refrigerated cases and refrain from purchasing any perishable products in the surrounding area. Furthermore, depending on the kind of instrumentation required to implement a particular DR strategy, technicians may be required to access the inner workings of the case. This is very labor-intensive and requires removal of a substantial amount of product from the case. The combination of labor intensiveness and possible after-hours schedule could significantly increase implementation labor costs, hampering the payback issues mentioned above.

DEMAND RESPONSE STRATEGIES AND POTENTIAL

There are three strategies for achieving DR in display cases presented below. For the purpose of this evaluation, the DR potential of each strategy is defined in Equation 1.

EQUATION 1. DEMAND RESPONSE POTENTIAL

$$DR_{potential} = (kW_{reduction}/unit) \times (Market\ Size) \times (Market\ Acceptance)$$

STRATEGY 1 – TEMPERATURE RESET

STRATEGY DESCRIPTION

Temperature reset requires raising the thermostat setpoint temperature by a few degrees. Depending on how the refrigeration system is set up, this can either cause the compressor and condenser (condensing unit) to cycle off because the setpoint is now satisfied, or reduce the load on a multiplex remote compressor set-up, thereby reducing its power consumption. In any case, the suction pressure will be raised slightly, allowing the refrigeration system to operate at slightly higher efficiency and reduced demand.

TECHNICAL DEMAND REDUCTION

If the condensing unit cycles off, there will be a 100% reduction in power until the various cooling loads warm the case to the new setpoint temperature. For remote systems tied into multiple compressor systems, there will be a reduction in refrigeration load but it will not necessarily lead to compressors shutting off completely. The duration of the off-cycle or reduced refrigeration load condition is completely dependent on the type of case involved and the overall cooling load effect of the surroundings, which will determine how quickly the case heats back up. Open cases will reach the new setpoint fairly quickly while closed cases will take more time due to their inherent isolation from the surroundings.

Where sustained DR is necessary, one option is to have multiple display case DR "groups" either within a site or across multiple sites. The groups can be rotated through short DR events to ensure they have coincident off-cycle times.

Because of all the variables involved, it is difficult to predict the actual demand reduction or duration, especially in an aggregate sense. The most realistic way to calculate the technical potential is to estimate total kW demand for the specified line-up lengths. Table 7 lists power demand for total length of each type of display case for three store sizes.

NOTE: For the purposes of the present exercise, the diversity effects mentioned above will intentionally be ignored because they are not included in Equation 1. As a result, the DR potential calculated here may not be realistically achievable for any significant duration of time.

TABLE 7. PER UNIT TOTAL DISPLAY CASE DEMAND FOR GIVEN STORE TYPES

EQUIPMENT CLASS	POWER DEMAND PER UNIT LENGTH (KW / FT)	TOTAL POWER DEMAND (KW)		
		SMALL	MEDIUM	LARGE
VOP.RC.M	0.192	36.9	73.7	92.2
SVO.RC.M	0.189	8.0	15.9	19.9
VCT.RC.M	0.056	0.7	1.4	1.8
HZO.RC.M	0.088	1.1	2.1	2.6
SOC.RC.M	0.107	1.3	2.6	3.2
VOP.RC.L	0.509	6.1	12.2	15.3
VCT.RC.L	0.13	17.4	34.8	43.4
TOTAL		**71.5**	**142.7**	**178.4**

MARKET ACCEPTANCE

The biggest foreseen acceptance barrier to this DR strategy for MT equipment is compliance with FDA Food Code.. The risk of spoilage and potential for resulting illness overshadows benefits realized in the minds of many store operators. Application to LT equipment does not appear to be a major issue because there is a much wider acceptable temperature range and less opportunity for product quality to be reduced. However, for open LT cases, this strategy will likely result in significant temperature swings that could damage product. As a result, the only equipment class it would be applicable to is VCT.RC.L.

Additionally, there may be technical complications in the implementation of this strategy due to the wide array of equipment and controllers that have to interface with the DR dispatching device.

There also may be a sector of the market that is not willing to relinquish any control of their equipment to a utility or other outside actor, similar to the experience of programmable communicating thermostats for residential air conditioners.

It is estimated that the market acceptance is approximately 50% for the VCT.RC.L class.

DEMAND RESPONSE POTENTIAL

Combining the display case DR potential from Table 7 and the market size information from Table 5, the DR achieved for various adoption rates on VCT. RC.L equipment is shown in Table 8.

TABLE 8. DR POTENTIAL FOR STRATEGY 1 FOR VARIOUS ADOPTION RATES

SIZE		1% ACCEPTANCE (KW)	5% ACCEPTANCE (KW)	10% ACCEPTANCE (KW)	20% ACCEPTANCE (KW)	50% ACCEPTANCE (KW)
Small	SCE	505	2,524	5,048	10,096	25,240
	CA	1,244	6,219	12,439	24,877	62,193
Med	SCE	1,758	8,788	17,575	35,151	87,876
	CA	4,330	21,652	43,304	86,608	216,520
Large	SCE	1,216	6,078	12,155	24,311	60,777
	CA	2,995	14,973	29,945	59,890	149,726
Total	**SCE**	**3,478**	**17,389**	**34,779**	**69,557**	**173,893**
	CA	**8,569**	**42,844**	**85,688**	**171,375**	**428,439**

STRATEGY 2 – LIGHTING REDUCTION

STRATEGY DESCRIPTION

Upon receiving a DR signal from the utility, lights in display cases will either shut off or switch to a dim state. Most cases in the field today are equipped with T8 fluorescent lamps that cannot be dimmed. A growing number of new cases are equipped with LED lighting, which can incorporate dimming strategies for energy efficiency gains. These dimming capabilities can be enabled during a DR event to provide prolonged low-power lighting.

TECHNICAL DEMAND REDUCTION

The lighting load for display cases with T8 lighting is typically around 28 Watts per foot. LED lighting demand is approximately 40% less than T8, or 16 W/ft. Table 9 details the potential DR reduction for several market share scenarios, assuming that T8 is turned completely off and LEDs are switched to 20% of maximum power. (Note, as existing cases are retrofitted to incorporate LED lighting, the total DR potential decreases because of the inherently lower power draw.) This measure applies to all display case types.

TABLE 9. DISPLAY CASE LIGHTING DR POTENTIAL PER SITE

T8 / LED MARKET SHARE	EQUIVALENT DR POTENTIAL (KW/FT)	TOTAL POWER DEMAND (KW)		
		SMALL	MEDIUM	LARGE
90% / 10%	0.0260	10.8	21.6	27.1
75% / 25%	0.0238	9.9	19.8	24.7
50% / 50%	0.0201	8.3	16.7	20.9

MARKET ACCEPTANCE

The biggest foreseen acceptance barrier to this DR strategy is customer perception. Because this strategy directly affects the merchantability aspects of the display case, merchandisers may be hesitant to adopt it. There is a fear that customers who see a case with the lights out will think that it is not working properly and the products inside are not good. This fear can be overcome using the LED dimming strategy or simply by placing signs in the aisle explaining why the lights are off. Signs of this nature have become more prevalent as companies are trying to promote their social consciousness through energy efficiency measures they have taken. It is estimated that the total market acceptance is 80%.

DEMAND RESPONSE POTENTIAL

Using the 90% T8/10% LED figures, which are closest to the present state of the market, and market size information from Table 5 the DR achieved for various adoption rates is shown in Table 10.

TABLE 10. DR POTENTIAL FOR STRATEGY 2 FOR VARIOUS ADOPTION RATES

SIZE		1% ACCEPTANCE (KW)	5% ACCEPTANCE (KW)	10% ACCEPTANCE (KW)	20% ACCEPTANCE (KW)	50% ACCEPTANCE (KW)
Small	SCE	314	1,572	3,144	6,287	15,718
	CA	775	3,873	7,746	15,492	38,730
Med	SCE	1,094	5,472	10,945	21,890	54,724
	CA	2,697	13,484	26,967	53,934	134,835
Large	SCE	757	3,785	7,570	15,139	37,848
	CA	1,865	9,324	18,648	37,296	93,240
Total	**SCE**	**2,166**	**10,829**	**21,658**	**43,316**	**108,290**
	CA	**5,337**	**26,681**	**53,361**	**106,722**	**266,806**

STRATEGY 3 – DAY-AHEAD DR TEMPERATURE PULL-DOWN

STRATEGY DESCRIPTION

In the event that the utility has advance knowledge that a DR event will be required the next day, display case temperatures may be pulled down in advance. During the DR event, the refrigeration equipment can be shut off and the temperature allowed to float up for a period of time until it reaches a maximum allowable temperature.

As with the temperature reset strategy, this is most suitable for LT applications. Pulling down temperature on MT equipment can bring temperatures close to freezing (32°F), which can damage the products on display. The duration of off time is dependent on the type of case involved and surrounding environmental effects. Open display cases are not good candidates because of their increased exposure to neighboring conditions. Closed cases are better candidates due to more effective thermal isolation from the surroundings.

TECHNICAL DEMAND REDUCTION

The potential DR for this measure is similar to that of Strategy 1, but should have longer duration due to the lower starting temperature. Because duration is not included in the DR potential calculation, there is no difference between this strategy and Strategy 1. Thus, the values in Table 7 apply here.

MARKET ACCEPTANCE

Just as in Strategy 1, the biggest foreseen acceptance barrier to this strategy is compliance with FDA Food Code. However, market acceptance may be slightly higher due to the advanced warning inherent in this strategy rather than an instantaneous change in operation.

It is estimated that the market acceptance is 60% for the VCT.RC.M equipment class.

DEMAND RESPONSE POTENTIAL

The total DR potential is the same as Strategy 1, so Table 8 applies.

RESULTS

DR potential for display cases range from 2,166 kW with 1% acceptance when lighting reductions are undertaken within SCE service territory to 428,439 kW with 50% acceptance for temperature reset or day-ahead pull down statewide. Table 11 shows the range of total DR potential for the two strategies identified.

TABLE 11. RANGE OF DR POTENTIAL

STRATEGY	1% ACCEPTANCE (KW)		50% ACCEPTANCE (KW)	
	SCE	CA	SCE	CA
Temp Reset / Day-Ahead Pull Down	3,478	8,569	173,893	428,439
Lighting Reduction	2,166	5,337	108,290	266,806

RECOMMENDATIONS

It is recommended that a codes and standards effort for Strategy 2, lighting reduction, move forward quickly. It would be easy to implement and would provide a significant amount of DR potential. Since lighting is not critical to the fitness of the products, it also will likely have a higher acceptance rate. Furthermore, many stores are on the verge of completing major retrofits to LED lighting systems once SCE rebates are in place early next year. This is a great opportunity to incorporate DR technology into the LED hardware, which might increase participation by allowing a dimming option rather than a fully off option.

Strategies 1 and 3 should also be pursued, but require further research to determine exactly how display cases will respond to DR events. The questions around duration of off-time and applicability to various display case types can only be answered through detailed technical testing. Significant industry involvement and buy-in are crucial to the implementation and success of these strategies.

APPENDIX

Equipment Family	Equipment Family Designation	Equipment Family Image	Operating Mode Designation	Temperature Designation	Equipment Class Designation
Vertical Open	VOP		RC	M (38°F)	VOP.RC.M
				L (0°F)	VOP.RC.L
				I (-15°F)	VOP.RC.I
			SC	M (38°F)	VOP.SC.M
				L (0°F)	VOP.SC.L
				I (-15°F)	VOP.SC.I
Semivertical Open	SVO		RC	M (38°F)	SVO.RC.M
				L (0°F)	SVO.RC.L
				I (-15°F)	SVO.RC.I
			SC	M (38°F)	SVO.SC.M
				L (0°F)	SVO.SC.L
				I (-15°F)	SVO.SC.I
Horizontal Open	HZO		RC	M (38°F)	HZO.RC.M
				L (0°F)	HZO.RC.L
				I (-15°F)	HZO.RC.I
			SC	M (38°F)	HZO.SC.M
				L (0°F)	HZO.SC.L
				I (-15°F)	HZO.SC.I
Vertical Closed Transparent	VCT		RC	M (38°F)	VCT.RC.M
				L (0°F)	VCT.RC.L
				I (-15°F)	VCT.RC.I
			SC	M (38°F)	VCT.SC.M*
				L (0°F)	VCT.SC.L*
				I (-15°F)	VCT.SC.I
Vertical Closed Solid	VCS		RC	M (38°F)	VCS.RC.M
				L (0°F)	VCS.RC.L
				I (-15°F)	VCS.RC.I
			SC	M (38°F)	VCS.SC.M*
				L (0°F)	VCS.SC.L*
				I (-15°F)	VCS.SC.I
Horizontal Closed Transparent	HCT		RC	M (38°F)	HCT.RC.M
				L (0°F)	HCT.RC.L
				I (-15°F)	HCT.RC.I
			SC	M (38°F)	HCT.SC.M*
				L (0°F)	HCT.SC.L*
				I (-15°F)	HCT.SC.I
Horizontal Closed Solid	HCS		RC	M (38°F)	HCS.RC.M
				L (0°F)	HCS.RC.L
				I (-15°F)	HCS.RC.I
			SC	M (38°F)	HCS.SC.M*
				L (0°F)	HCS.SC.L*
				I (-15°F)	HCS.SC.I
Service Over Counter	SOC		RC	M (38°F)	SOC.RC.M
				L (0°F)	SOC.RC.L
				I (-15°F)	SOC.RC.I
			SC	M (38°F)	SOC.SC.M*
				L (0°F)	SOC.SC.L*
				I (-15°F)	SOC.SC.I

* These equipment classes have standards established by EPACT 2005 and are therefore not covered under this rulemaking.

FIGURE 4. DOE DISPLAY CASE EQUIPMENT CLASSES

REFERENCES

[1] DOE Commercial Refrigeration Equipment Final Rule Technical Support Document. pp. 3-18. http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/chp_3_cre_mta.pdf

[2] DOE Commercial Refrigeration Equipment Final Rule Technical Support. http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/cre_final_rule.pdf

[3] Id. At p.3.

[4] California Energy Commission (CEC). California Commercial End-Use Survey (CEUS) http://www.energy.ca.gov/ceus/index.html, accessed December 2009

[5] Itron. 2006. "California Commercial End-Use Survey: Consultant Report," CEC-400-2006-005. pp 27, 29, 42, 68-69. http://capabilities.itron.com/CeusWeb/Default.aspx, accessed November 2009.

[6] Id. http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/chp_7_cre_energy_final.pdf p 7-10