
Energy & Store
Development
Conference
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FMI
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California 2013 Title 24 Supermarket Refrigeration

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Topics

- Background and current practice
- Proposed Title 24 requirements
- Measure savings and economics

Background

- California building energy efficiency code (Title 24) reviewed periodically.
  - Current 2008 code– effective 1/1/2010
  - Proposed 2013 revision– to be effective 1/1/2014
- California Energy Commission (CEC) and California Air Resources Board (CARB) cooperated to evaluate supermarket refrigeration measures
  - CEC addressed energy savings
  - CARB addressed emissions and leak reduction measures
- First time Title 24 has included direct GHG emissions, using total CO_2 valuation

Objectives and Process

- Achieve significant energy savings through the development of reasonable, responsible, and cost-effective code change proposals for the 2013 code update and beyond
- Investor owned utilities (IOUs) completed initial process for CEC, including stakeholder meetings held to obtain industry input and feedback on code change proposals
- CEC holds public meetings to review and finalize code proposals

Title 24 Code Change Activities

- 2013 Base Code (Part 6 of Title 24)
- 2013 Reach Standard (Part 11 of Title 24)
  - Green Building Standard – i.e. CalGreen

- Identify topics for future codes
  - 2016 Title 24
  - Future Reach Standards

Types of Code Requirements

- Mandatory Measures:
  - All proposed supermarket refrigeration measures are mandatory measures
- Prescriptive Measures: N/A
- Performance Compliance Option: N/A
- *CEC would like a performance option for the 2016 code cycle, requiring:*
  - *Modeling software to define/apply energy budget*
  - *Equipment performance data*

Requirements for Base Code Measures

- A measure must be cost-effective:
  - Based on the standards-induced additional first cost, maintenance costs, measure life, and energy cost savings, according to the CEC Time Dependent Valuation (TDV) life-cycle costing methodology and weather data
- A measure must be possible to implement:
  - Using equipment that is available from multiple providers, or that is reasonably expected to be available following the code change

Previous Process and Future Dates

- Stakeholder meetings:
  - Meeting at CARB April, 2010
  - Three Codes and Standards Program meetings including FMI in Minneapolis September 2010
  - CEC public workshop April 2011
- CEC opens Rulemaking: September 2011
- Title 24 CEC Adoption: March 2012
- CBSC Publication: July 2013
- Title 24 Implementation: Jan 1, 2014

Current Code Requirements

- Title 20 (CA Appliance Standard) and Federal walk-in requirements:
  - ECM motors
  - Insulation levels, strip curtains, lighting
  - Door heater wattage
- Display cases:
  - 2012 Federal remote display case regulations expressed in daily energy use (kWh/day)
- No existing Title 24 supermarket refrigeration requirements

Current Code Requirements

- Refrigerated Warehouse 2008 Title 24 requirements – similarities and differences:
  - Floating head pressure to 70 F with variable speed fan and variable setpoint logic
    - Same as proposed for supermarkets
  - Evaporator fan variable speed control
    - Proposed and evaluated for supermarkets but deferred
  - Condenser sizing requirements
    - In contrast, supermarket standard addressed specific efficiency in lieu of condenser sizing

Typical Supermarket Refrig. Practice

- Typical new construction practice – common measures from 2001-2010 Savings By Design IOU incentive programs:
  - Floating head pressure to 70 F
  - Floating suction pressure control
  - Subcooling (at least on LT)
  - Variable speed condenser control (nearly 100% on evap condensers and ~50% on air-cooled)
  - History of condenser specific efficiencies

Analysis Methodology

- Energy analysis using DOE2.2R simulation
- Base case via Savings By Design experience
- Time dependent valuation (TDV)
  - Energy valuation based on time of day
- 15 years life for all refrigeration measures
- Measures evaluated with Benefit/Cost Ratio
  - Total life-cycle TDV value / incremental cost plus discounted maintenance or replacement costs
  - BCR is primary determinant of cost effectiveness

Analysis Methodology

Year	Base Case Carbon Forecast ($/ton CO2eq)
2011	$ 13.98
2012	15.37
2013	16.89
2014	19.87
2015	22.85
2016	26.05
2017	29.26
2018	32.70
2019	36.14
2020	39.84
2021	43.67
2022	47.51
2023	51.62
2024	55.73
2025	60.13

- CEC developed economic value of direct and indirect carbon equivalent emissions
- Used to evaluate cost of direct HFC emissions for certain measures

Simulation Tool

- DOE 2.2R whole building hourly simulation
  - Fixtures loads disaggregated, balance space interactions (fixture, HVAC, building, etc.)
  - Mass-flow/component based refrigeration system modeling, explicit control strategies
  - Modeling of building envelope, HVAC, lighting, skylights, etc.

Base Case Assumptions

- Title 24 compliant building
  - Insulation, lighting power density, HVAC systems
  - Code level skylights and light level control
- Display cases
  - T-8 lights, EC motors, low watt glass door heaters
- Walk-ins
  - Federal Walk-in standard compliant
- Refrigeration systems
  - Partial floating head pressure, fixed suction, no subcooling
- Schedules: operations, occupancy, lighting, etc.

Store and System Analysis Types

Supermarket Prototype	Condenser Type	Compressor System	Designation
Small Supermarket (10,000 SF)	Air-cooled	Central	SAC
		Distributed	SAD
	Evaporative-cooled	Central	SEC
	Fluid cooler	Central	SFC
		Distributed	SFD
Large Supermarket (60,000 SF)	Air-cooled	Central	MAC
		Distributed	MAD
	Evaporative-cooled	Central	MEC
	Fluid cooler	Central	MFC
		Distributed	MFD
Big Box Store (150,000 SF)	Air-cooled	Central	LAC
		Distributed	LAD
	Evaporative-cooled	Central	LEC
	Fluid cooler	Central	LFC
		Distributed	LFD

Title 24 Base Code Measures

- Floating head pressure
- Remote condenser specific efficiency
- Floating suction pressure
- Mechanical subcooling
- Display case lighting control
- Prohibit open upright low temperature cases
- Heat recovery for space heating

Reach Code Measure

- CO_2 secondary (indirect) or cascade cooling

Proposed Code Language

- Primary source: April 2011 Draft CASE (Codes and Standards Enhancement) Report

  plus, subsequent changes by CEC based on stakeholder input
- Black text in following slides is based on proposed code language

Information is proposed not final and is subject to change

Applicability

Retail food stores with **8,000 square feet** or more of conditioned area or more, and that utilize either refrigerated display cases, or walk-in coolers or freezers connected to **remote** compressor units or condensing units, shall meet the requirements of this section.

- New construction:
  - Includes remodels and expansions with certain exceptions

Definitions

- **BUBBLE POINT** is the refrigerant liquid saturation temperature at a specified pressure.
- **DEW POINT** is the refrigerant vapor saturation temperature at a specified pressure.
- **COOLER** is space greater than or equal to 28 F but less than 55 F.
- **FREEZER** is space designed to maintain less than 28 F and space designed for convertible between cooler and freezer operation.

Definitions

- **SATURATED CONDENSING TEMPERATURE (CONDENSING TEMPERATURE)** is the saturation temperature corresponding to the refrigerant pressure at the condenser entrance for single component and azeotropic refrigerants. For zeotropic refrigerants, the arithmetic **average of the Dew Point and Bubble Point** temperatures corresponding to the refrigerant pressure at the condenser entrance.

Definitions

- **CONDENSER SPECIFIC EFFICIENCY** is the Total Heat of Rejection (THR) capacity divided by the fan input electric power at 100% fan speed (including spray pump electric input power for evaporative condensers).

Definitions

- **MICRO-CHANNEL CONDENSER** is an air-cooled condenser for refrigeration systems which utilizes multiple small parallel gas flow passages in a flat configuration with unitized fin surface between the gas passages, rather than round tubes arranged at a right angle to separate plate fins.
- **TOTAL HEAT OF REJECTION** (THR) is the heat absorbed at the evaporator plus the heat picked up in the suction line plus the heat added to the refrigerant in the compressor.

Floating Head Pressure

- All condenser fans for air-cooled condensers, evaporative-cooled condensers, air- or water-cooled fluid coolers or cooling towers shall be continuously **variable speed**, with the speed of **all fans** serving a common condenser high side **controlled in unison**.

Floating Head Pressure

- The refrigeration system condenser controls for systems with air-cooled condensers shall use **variable-setpoint control** logic to reset the condensing temperature setpoint in response to ambient drybulb temperature.
  - EXCEPTION: Condensing temperature control strategies approved by the Executive Director that have been demonstrated to provide equal energy savings
- The minimum condensing temperature setpoint shall be **less than or equal to 70˚F.**

Floating Head Pressure

	Energy Savings (kWh)	Energy Savings/ SF (kWh)	TDV Cost Savings ($)	TDV Cost Savings /SF ($)	Measure Cost ($)	Benefit/ Cost Ratio
SXX Average	25,989	1.64	$49,532	$3.13	$13,923	3.56
MXX Average	94,194	1.58	$162,842	$2.73	$35,251	4.62
LXX Average	121,870	0.75	$212,155	$1.31	$39,436	5.38
XAX Average	124,636	2.08	$222,211	$3.80	$33,055	6.72
XEX Average	50,565	0.76	$97,711	$1.60	$27,191	3.59
XFX Average	51,792	0.85	$82,707	$1.38	$27,191	3.04

All Average						
CTZ01 - Arcata	91,871	1.49	$165,461	$2.700	$29,537	5.60
CTZ03 - Oakland	81,873	1.34	$148,540	$2.441	$29,537	5.03
CTZ05 - Santa Maria	84,642	1.39	$153,901	$2.532	$29,537	5.21
CTZ07 - San Diego-Lindbergh	68,631	1.16	$130,996	$2.208	$29,537	4.43
CTZ08 - Fullerton	75,743	1.27	$150,307	$3.129	$29,537	5.09
CTZ10 - Riverside	79,688	1.31	$131,868	$2.165	$29,537	4.46
CTZ12 - Sacramento	83,625	1.37	$139,958	$2.294	$29,537	4.74
CTZ13 - Fresno	80,300	1.32	$133,652	$2.194	$29,537	4.52
CTZ14 - Palmdale	90,771	1.47	$146,744	$2.382	$29,537	4.97
CTZ15 - Palm Springs	69,697	1.13	$113,670	$1.848	$29,537	3.85

FHP – WBT Sensor Error Evaluation

- Investigated sensitivity of sensor error on evaporative condensers.
  - Concern was drift of RH sensor reading used for wetbulb temperature calculation.
- Analysis determined that evaporative condenser ambient-following control is cost-effective even with significant sensor error.

FHP – Charge Impact Evaluation

- Evaluated potential charge impacts
  - FHP methods could increase charge and/or increase potential for leakage
- Analysis determined that energy savings far outweigh potential direct GHG increase

Condenser Specific Efficiency

- Fan-powered condensers shall meet the (following) specific efficiency requirements:

Condenser Type	Minimum Specific Efficiency	Rating Condition
Evaporative-Cooled	160 (Btu/h)/W	100˚F Saturated Condensing Temperature (SCT), 70˚F Entering Wetbulb Temperature
Air-Cooled	65 (Btu/h)/W	105˚F Saturated Condensing Temperature (SCT), 95˚F Entering Drybulb Temperature

Condenser Specific Efficiency

- **EXCEPTION 1:** Condensers with a THR capacity of less than 150 MBH at the specific efficiency rating condition.
- **EXCEPTION 2:** Stores located in Climate Zone CTZ01.
- **EXCEPTION 3:** Existing condensers that are reused for an expansion or remodel.

- Air-cooled condensers shall have a fin density no greater than 10 fins per inch.
  - **EXCEPTION 1:** Micro-channel condensers.
  - **EXCEPTION 2:** Existing condensers that are reused for an expansion or remodel.

Condenser Specific Efficiency

	Energy Savings (kWh)	Energy Savings/ SF (kWh)	TDV Cost Savings ($)	TDV Cost Savings /SF ($)	Measure Cost ($)	Benefit/ Cost Ratio
SXX Average	2,037	0.10	$5,038	$0.30	$1,656	5.41
MXX Average	6,449	0.11	$18,003	$0.30	$3,599	8.41
LXX Average	6,184	0.04	$19,679	$0.13	$5,696	4.46
XAX Average	5,755	0.10	$17,419	$0.29	$5,526	3.52
XEX Average	1,867	0.03	$3,471	$0.06	$795	13.13

All Average						
CTZ01 - Arcata	1,507	0.03	$3,353	$0.062	$3,571	3.72
CTZ03 - Oakland	2,181	0.04	$5,533	$0.102	$3,571	4.29
CTZ05 - Santa Maria	2,438	0.04	$4,569	$0.084	$3,571	4.01
CTZ07 - San Diego-Lindbergh	2,937	0.05	$6,586	$0.121	$3,571	4.65
CTZ08 - Fullerton	3,268	0.06	$10,472	$0.185	$3,901	5.21
CTZ10 - Riverside	5,353	0.09	$19,110	$0.323	$3,901	6.94
CTZ12 - Sacramento	4,540	0.08	$17,493	$0.295	$3,901	6.55
CTZ13 - Fresno	6,692	0.11	$21,812	$0.364	$3,901	7.47
CTZ14 - Palmdale	6,629	0.11	$21,694	$0.362	$3,901	7.15
CTZ15 - Palm Springs	13,409	0.23	$33,395	$0.555	$3,901	10.32

Condenser Specific Efficiency

- Required specific efficiency are only slightly higher than the incentive program base case efficiencies since 2002.
  - 160 vs. 140 for evaporative condensers
  - 65 vs. 53 for air cooled condensers
- Considerations:
  - Catalog capacities are not certified ratings
  - Motor ratings are nameplate ratings and applied power could be higher or lower
  - First generation condensers with EC motors had low efficiencies—better options appear to be coming to market

Floating Suction Pressure

- Compressors and multiple-compressor suction groups shall include control systems that use **floating suction pressure** logic to reset the target saturated suction temperature based on the temperature requirements of the attached refrigeration display cases or walk-ins.
  - **EXCEPTION 1:** Single compressor systems that do not have continuously variable capacity capability.
  - **EXCEPTION 2:** Suction groups that have a design saturated suction temperature of 30˚F or higher, or suction groups that comprise the high stage of a two-stage or cascade system or that primarily serve chillers for secondary cooling fluids.

Floating Suction Pressure

	Energy Savings (kWh)	Energy Savings/ SF (kWh)	TDV Cost Savings ($)	TDV Cost Savings /SF ($)	Measure Cost ($)	Benefit/ Cost Ratio
SXX Average	8,428	0.53	$16,508	$1.04	$5,075	3.25
MXX Average	33,799	0.57	$65,475	$1.10	$10,149	6.45
LXX Average	50,213	0.31	$98,996	$0.61	$10,149	9.75
XAX Average	30,047	0.46	$60,311	$0.93	$8,458	7.13
XEX Average	26,407	0.39	$50,531	$0.75	$8,458	5.97
XFX Average	33,782	0.51	$65,240	$0.99	$8,458	7.71

All Average						
CTZ01 - Arcata	28,549	0.44	$54,689	$0.841	$8,458	6.47
CTZ03 - Oakland	29,510	0.45	$57,071	$0.874	$8,458	6.75
CTZ05 - Santa Maria	29,299	0.45	$56,655	$0.868	$8,458	6.70
CTZ07 - San Diego-Lindbergh	29,996	0.46	$58,013	$0.891	$8,458	6.86
CTZ08 - Fullerton	30,339	0.46	$58,700	$0.889	$8,458	6.94
CTZ10 - Riverside	31,196	0.47	$61,242	$0.926	$8,458	7.24
CTZ12 - Sacramento	30,864	0.47	$61,459	$0.932	$8,458	7.27
CTZ13 - Fresno	31,935	0.49	$63,559	$0.963	$8,458	7.51
CTZ14 - Palmdale	31,286	0.47	$61,882	$0.932	$8,458	7.32
CTZ15 - Palm Springs	35,156	0.53	$69,995	$1.055	$8,458	8.28

Floating Suction Pressure

- Standard practice in most stores
  - FSP logic standard in rack controllers
  - Temperature sensors in cases and walk-ins (needed for FSP) are standard practice
- Requires coordination with other controls such as electronic suction regulators
- Measure cost is primarily labor to program, fine-tune and maintain

Mechanical Subcooling

- Liquid subcooling shall be provided for all low temperature parallel compressor systems with a design saturated suction temperature of -10˚F or lower, with the subcooled liquid temperature maintained continuously at 50˚F or less at the subcooler exit, using compressor economizer port(s) or a separate parallel medium or high temperature suction group operating at a saturated suction temperature of 18˚F or higher.

Mechanical Subcooling

- **EXCEPTION 1:** Single compressor systems.
- **EXCEPTION 2:** Low temperature cascade systems that condense into another refrigeration system rather than condensing to ambient temperature.
- **EXCEPTION 3:** Existing compressors that are reused for an expansion or remodel.

Mechanical Subcooling

	Energy Savings (kWh)	Energy Savings/ SF (kWh)	TDV Cost Savings ($)	TDV Cost Savings /SF ($)	Measure Cost ($)	Benefit/ Cost Ratio
SXX Average	9,012	0.57	$18,543	$1.17	$4,475	4.14
MXX Average	25,483	0.43	$53,461	$0.90	$7,973	6.71
LXX Average	65,849	0.41	$137,909	$0.85	$14,221	9.70
XAX Average	26,748	0.37	$64,115	$0.87	$8,694	7.37
XEX Average	26,739	0.37	$51,989	$0.71	$9,673	5.37
XFX Average	43,502	0.62	$84,818	$1.20	$8,694	9.76

All Average						
CTZ01 - Arcata	28,837	0.41	$54,668	$0.772	$8,890	6.15
CTZ03 - Oakland	29,735	0.42	$58,467	$0.815	$8,890	6.58
CTZ05 - Santa Maria	29,532	0.42	$57,315	$0.800	$8,890	6.45
CTZ07 - San Diego-Lindbergh	31,193	0.44	$62,173	$0.866	$8,890	6.99
CTZ08 - Fullerton	32,359	0.46	$66,352	$0.946	$8,890	7.46
CTZ10 - Riverside	34,136	0.48	$74,327	$1.025	$8,890	8.36
CTZ12 - Sacramento	33,135	0.46	$72,075	$0.996	$8,890	8.11
CTZ13 - Fresno	35,542	0.49	$77,962	$1.076	$8,890	8.77
CTZ14 - Palmdale	34,923	0.48	$75,368	$1.036	$8,890	8.48
CTZ15 - Palm Springs	45,087	0.62	$101,004	$1.397	$8,890	11.36

Display Case Lighting Control

- Lighting in refrigeration display cases, and lights on glass doors installed on walk-in coolers and freezers shall be controlled by either A or B:
  A. Automatic time switch controls to turn off lights during non-business hours. Use of timed overrides to turn the lights for stocking shall not exceed one hour for any case line-up or walk-in and if manually imitated shall time-out automatically.
  B. Motion sensor controls on each case that reduce display case lighting power by at least 50% within 30 minutes after the area near the case is vacated.
  - **EXCEPTION 1:** Stores which are normally open for business 140 hours or more per week.

Display Case Lighting Control

	Energy Savings (kWh)	Energy Savings/ SF (kWh)	TDV Cost Savings ($)	TDV Cost Savings /SF ($)	Measure Cost ($)	Benefit/ Cost Ratio
SXX Average	49,627	3.13	$69,134	$4.36	$5,588	12.37
MXX Average	149,814	2.52	$219,138	$3.68	$11,321	19.36
LXX Average	173,263	1.07	$265,992	$1.64	$12,659	21.01
XAX Average	122,362	2.21	$181,772	$3.18	$9,856	18.44
XEX Average	121,355	2.19	$180,092	$3.15	$9,856	18.27
XFX Average	127,547	2.29	$190,068	$3.31	$9,856	19.28

All Average						
CTZ01 - Arcata	121,760	2.20	$182,231	$3.189	$9,856	18.49
CTZ03 - Oakland	122,526	2.21	$181,454	$3.173	$9,856	18.41
CTZ05 - Santa Maria	122,016	2.20	$182,338	$3.183	$9,856	18.50
CTZ07 - San Diego-Lindbergh	125,402	2.26	$189,148	$3.292	$9,856	19.19
CTZ08 - Fullerton	124,593	2.24	$184,423	$3.209	$9,856	18.71
CTZ10 - Riverside	124,596	2.24	$182,220	$3.174	$9,856	18.49
CTZ12 - Sacramento	123,529	2.22	$184,090	$3.210	$9,856	18.68
CTZ13 - Fresno	125,199	2.26	$187,412	$3.293	$9,856	19.01
CTZ14 - Palmdale	124,213	2.24	$182,442	$3.195	$9,856	18.51
CTZ15 - Palm Springs	128,513	2.31	$191,788	$3.356	$9,856	19.46

Prohibit Open Upright Frozen Food Cases

- Upright low temperature display cases that are designed for a supply air temperature of 5˚F or lower shall utilize reach-in glass doors.

- No incremental capital cost increase
- Energy impact: 12 ft. open case vs. 5 doors
  - 10,000 kWh annual savings

Heat Recovery for Space Heating

- HVAC systems shall utilize heat recovery from refrigeration system(s) for space heating, using no less than **25% of the sum of the design Total Heat of Rejection** of all refrigeration systems that have individual Total Heat of Rejection values of **150,000 BTU/Hr** or greater at design conditions.
  - **EXCEPTION 1:** Stores located in Climate Zone CTZ15.
  - **EXCEPTION 2:** HVAC systems that are reused for an expansion or remodel.

Heat Recovery for Space Heating

- The increase in HFC refrigerant charge associated with refrigeration heat recovery equipment and piping shall be no greater than 0.35 lbs per 1,000 BTU/Hr of heat recovery heating capacity.

Heat Recovery for Space Heating

	Energy Savings (kWh)	Energy Savings/ SF (kWh)	Natural Gas Savings (Therms)	Natural Gas Savings /SF (Therms)	TDV Cost Savings ($)	TDV Cost Savings /SF ($)	Measure Cost ($)	Benefit/ Cost Ratio
SXX Average	-15,885	-1.00	7,573	0.48	$126,510	$7.98	$21,396	5.91
MXX Average	-37,045	-0.62	26,572	0.45	$478,112	$8.03	$69,949	6.84
LXX Average	-94,772	-0.58	35,118	0.22	$540,915	$3.34	$88,378	6.12
XAX Average	-70,370	-1.10	23,006	0.38	$336,229	$5.68	$60,813	5.53
XEX Average	-53,986	-0.80	23,061	0.38	$371,734	$6.31	$57,021	6.52
XFX Average	-25,722	-0.34	23,183	0.38	$432,518	$7.29	$60,446	7.16

All Average								
CTZ01 - Arcata	-53,400	-0.78	43,977	0.69	$771,752	$12.350	$59,908	12.88
CTZ03 - Oakland	-48,367	-0.70	31,436	0.50	$545,607	$8.881	$59,908	9.11
CTZ05 - Santa Maria	-49,166	-0.71	33,001	0.53	$568,282	$9.204	$59,908	9.49
CTZ07 - San Diego-Lindbergh	-41,375	-0.59	17,696	0.31	$284,389	$5.273	$59,908	4.75
CTZ08 - Fullerton	-46,948	-0.73	16,646	0.32	$256,694	$5.284	$59,908	4.28
CTZ10 - Riverside	-49,868	-0.75	16,704	0.28	$257,436	$4.394	$59,908	4.30
CTZ12 - Sacramento	-53,112	-0.80	23,756	0.39	$399,091	$6.596	$59,908	6.66
CTZ13 - Fresno	-50,693	-0.77	19,960	0.33	$331,549	$5.523	$59,908	5.53
CTZ14 - Palmdale	-56,213	-0.86	21,598	0.35	$358,692	$5.910	$59,908	5.99
CTZ15 - Palm Springs	-43,199	-0.67	6,096	0.11	$44,962	$1.073	$59,908	0.75

Heat Recovery – Charge Impacts

	Measure Cost ($)	Refrigerant Cost Savings Range ($)		TDV Energy Cost Savings ($)	Carbon Cost Savings Range ($)		Net Savings ($)	
		High	Low		High	Low	High	Low
SXX Average	$21,396	-$2,414	-$3,956	$126,510	$1,233	-$9,435	$103,934	$91,722
MXX Average	$69,949	-$12,144	-$19,905	$478,112	-$17,192	-$70,876	$378,828	$317,383
LXX Average	$88,378	-$14,315	-$23,465	$540,915	-$24,105	-$89,836	$414,117	$339,236
XAX Average	$60,813	-$9,922	-$16,124	$336,229	-$20,096	-$63,813	$245,397	$195,479
XEX Average	$57,021	-$16,357	-$27,262	$371,734	-$61,883	-$138,755	$236,473	$148,697
XFX Average	$60,446	-$5,959	-$9,683	$432,518	$17,653	-$8,599	$383,766	$353,790

All Average								
CTZ01 - Arcata	$59,908	-$9,624	-$15,775	$771,752	$44,374	$1,013	$746,594	$697,082
CTZ03 - Oakland	$59,908	-$9,624	-$15,775	$545,607	$10,245	-$33,117	$486,320	$436,807
CTZ05 - Santa Maria	$59,908	-$9,624	-$15,775	$568,282	$14,468	-$28,893	$513,219	$463,706
CTZ07 - San Diego-Lindbergh	$59,908	-$9,624	-$15,775	$284,389	-$26,838	-$70,200	$188,019	$138,507
CTZ08 - Fullerton	$59,908	-$9,624	-$15,775	$256,694	-$30,944	-$74,305	$156,219	$106,706
CTZ10 - Riverside	$59,908	-$9,624	-$15,775	$257,436	-$31,391	-$74,753	$156,513	$107,001
CTZ12 - Sacramento	$59,908	-$9,624	-$15,775	$399,091	-$12,284	-$55,646	$317,275	$267,762
CTZ13 - Fresno	$59,908	-$9,624	-$15,775	$331,549	-$22,429	-$65,790	$239,589	$190,076
CTZ14 - Palmdale	$59,908	-$9,624	-$15,775	$358,692	-$18,987	-$62,349	$270,173	$220,661
CTZ15 - Palm Springs	$59,908	-$9,624	-$15,775	$44,962	-$59,755	-$103,117	-$84,324	-$133,837

Heat Recovery for Space Heating

- Analysis based on full heat recovery
- Code requirement is only 25% of design THR to allow for many combinations of:
  - Refrigeration systems types
  - HVAC system types and configurations
  - Store sizes and layouts
  - New construction project types

CO^2 Secondary or Cascade Cooling

- Title 24 Part 11 Green Building Standards
  - Voluntary or "Reach" measure: easily adopted, standardized approach for jurisdictions wishing to implement a more stringent code
- Benefit is reduced direct GHG emissions
  - Measure with equal or slightly higher energy use, justified on lower total CO_2 emissions.
- Energy impacts neutral or negative
  - CO_2 indirect approximately equal to DX
  - CO_2 cascade slightly higher than CO_2 indirect
  - Glycol increases energy usage significantly

CO^2 Secondary or Cascade Cooling

- Cooling for all refrigerated display cases and walk-in coolers and freezers shall be provided using carbon dioxide (CO_2), connected to compressors as a direct expansion refrigerant, or as a phase-change indirect cooling fluid.
  - **EXCEPTION 1:** Stores with less than 20,000 square feet of sales area.
  - **EXCEPTION 2:** Existing compressor systems that are reused for an expansion or remodel.

CO^2 Secondary or Cascade Cooling

- **EXCEPTION 3:** For the medium temperature display cases and coolers use of indirect **glycol** cooling including the following:
  - Stores with a total medium temperature fixtures and walk-in cooling load of **360,000 BTU/Hr or greater** shall have at least one glycol chiller designed with a glycol supply temperature **no lower than 25˚F**.
  - Glycol supply **pump(s) equipped with variable speed** drives controlled based on glycol loop pressure differential and with two-way (no bypass) type control valves at cooling coils and display cases.
  - Variable **speed control on walk-in cooling coil fans**, utilizing speed control as primary temperature control before cycling glycol supply valves, with minimum fan speed no greater than 70%.

Recent proposed language to allow glycol with provisions to achieve minimum energy penalty.

Still being studied.

CO^2 Secondary or Cascade Cooling

Recent proposed language to allow low GWP option (e.g. HFO) when available

- **EXCEPTION 4:** Direct expansion systems using a Low-GWP refrigerant.

- **LOW-GWP REFRIGERANT** means a compound used as a heat transfer fluid or gas that is: (A) any compound or blend of compounds, with a **GWP Value less than 150**; and (B) U.S. EPA Significant New Alternatives Policy (SNAP)-approved; and (C) not an ozone depleting substance as defined in Title 40 of the Code of Federal Regulations, Part 82, §82.3 (as amended March 10, 2009).

- **EXCEPTION 5:** Self-contained refrigerated display cases.

Acceptance Testing

- Acceptance testing of control-related measures will be required as part of code compliance.
- Acceptance testing procedures will be developed once measures are adopted.

- Will contact chains to assist in “dry run” of acceptance testing procedures.

Rejected or Deferred Measures

- Evaporator coil specific efficiency
  - Large potential but too complex
  - Issue of no standard ratings or certification
- Display case LED lights
  - Federal preemption
- Display case night curtains
  - Not cost-effective

Rejected or Deferred Measures

- Prohibit hot gas defrost (reduced leakage)
  - Results too uncertain
- Walk-in variable speed fan control
  - Large potential but cost and performance concerns were not resolved
- Liquid-suction heat exchangers
  - Large potential savings but leakage concern was not resolved

QUESTIONS

Information:
www.energy.ca.gov/title24/2013standards/prerulemaking
www.calcodesgroup.com
www.h-m-g.com/T24/supermarket%20refrig/supermarketrefrig.htm

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