

Energy & Store
Development
Conference

E+SD²⁰¹¹



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 CO₂ 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 |
| Large Supermarket (60,000 SF) | Air-cooled | Distributed | SFD |
| | | Central | MAC |
| | Evaporative-cooled | Central | MAD |
| | | Fluid cooler | Central |
| Big Box Store (150,000 SF) | Air-cooled | Central | MFC |
| | | Distributed | MFD |
| | Evaporative-cooled | Central | LAC |
| | | Fluid cooler | Central |
| Fluid cooler | Central | LEC | |
| | Distributed | 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

- CO₂ 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 |
| AFX 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.
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- 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 |
| AFX 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

CO₂ 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 CO₂ emissions.
- Energy impacts neutral or negative
 - CO₂ indirect approximately equal to DX
 - CO₂ cascade slightly higher than CO₂ indirect
 - Glycol increases energy usage significantly

CO₂ Secondary or Cascade Cooling

- Cooling for all refrigerated display cases and walk-in coolers and freezers shall be provided using carbon dioxide (CO₂), 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.

CO² Secondary or Cascade Cooling

- **EXCEPTION 3:** For the medium temperature display cases and coolers use of indirect **glycol** cooling including the following:

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

Still being studied.

- 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%.

CO² 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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