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2008 Title 24 Refrigerated Warehouse CASE Initiative

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Pacific Gas and
Electric Company.

Codes & Standards Enhancement Project

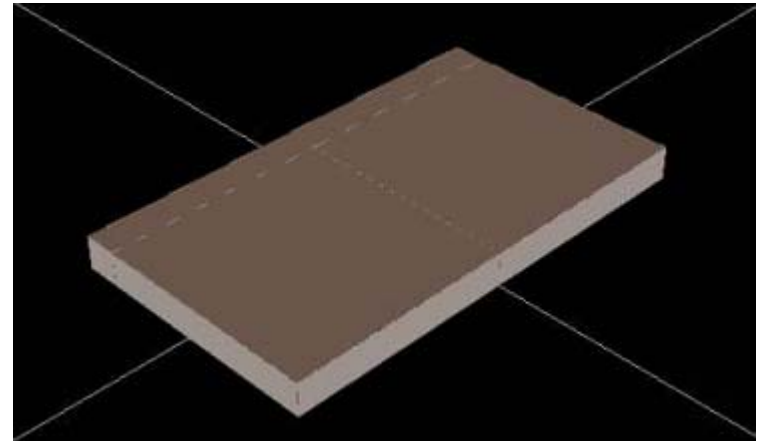
Background Research

- Literature review
 - Utility efficiency programs
 - ASHRAE “Design Essentials for RWBs”
 - Purdue study for IARW
 - Pacific Northwest VFD Evaporator Fan Initiative
 - DEER measure cost study
 - Manufacturers’ data
- Contractor and designer telephone surveys
- DOE-2 simulations



Prototype Refrigerated Warehouse Simulations

- DOE-2.2R simulation program used
- Ammonia based system with screw compressors and evaporative condenser
- 92,000 SF
- Combination of freezer, cooler and shipping dock space
- See report for details



Areas Addressed

- Evaporators
- Condensers
- Compressors
- Lighting
- Insulation levels
- Under floor heat
- Defrost



Evaporator Fan VSD



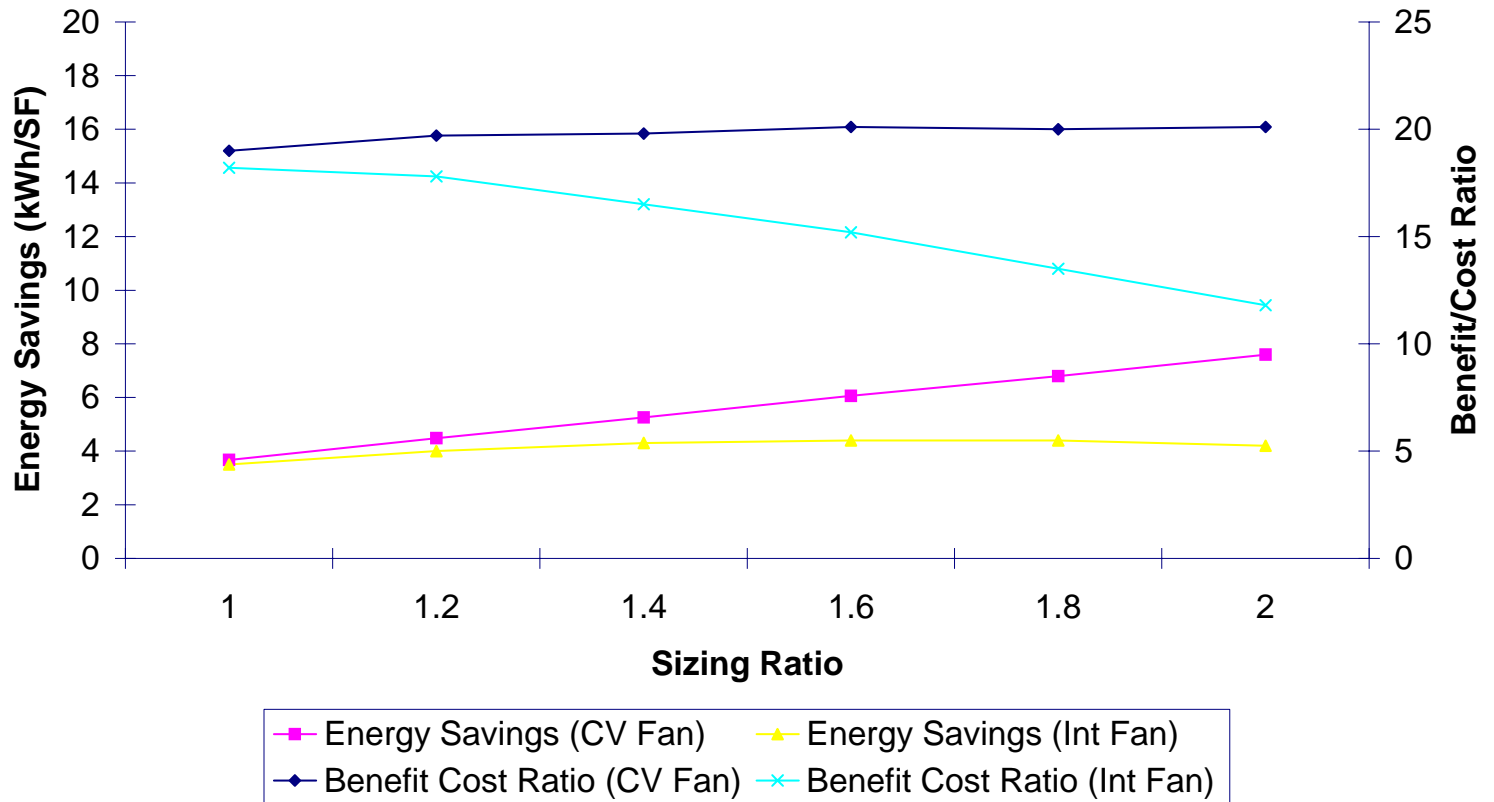
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Evaporator Fan VSD Analysis

- Used hourly “Time Dependent Valuation” costs,
 - 15 year measure life,
 - 3% real (net of inflation) discount rate
- Impact of over-sizing investigated
- Evaporator fan VSD costs of \$577 per hp from the Northwest Energy Efficiency Alliance
 - Demonstrated energy savings
 - Reduced fruit mass loss in controlled atmosphere rooms
- Graph of savings (kWh/SF) and Benefit/Cost ratio versus over-sizing ratio
 - Greater over-sizing, greater savings
 - B/C ratio of 20 to 1 fairly constant for CV fans, above 10 for intermittent fans



Evaporator Fan VSD Energy Savings and Cost Effectiveness



Compressors



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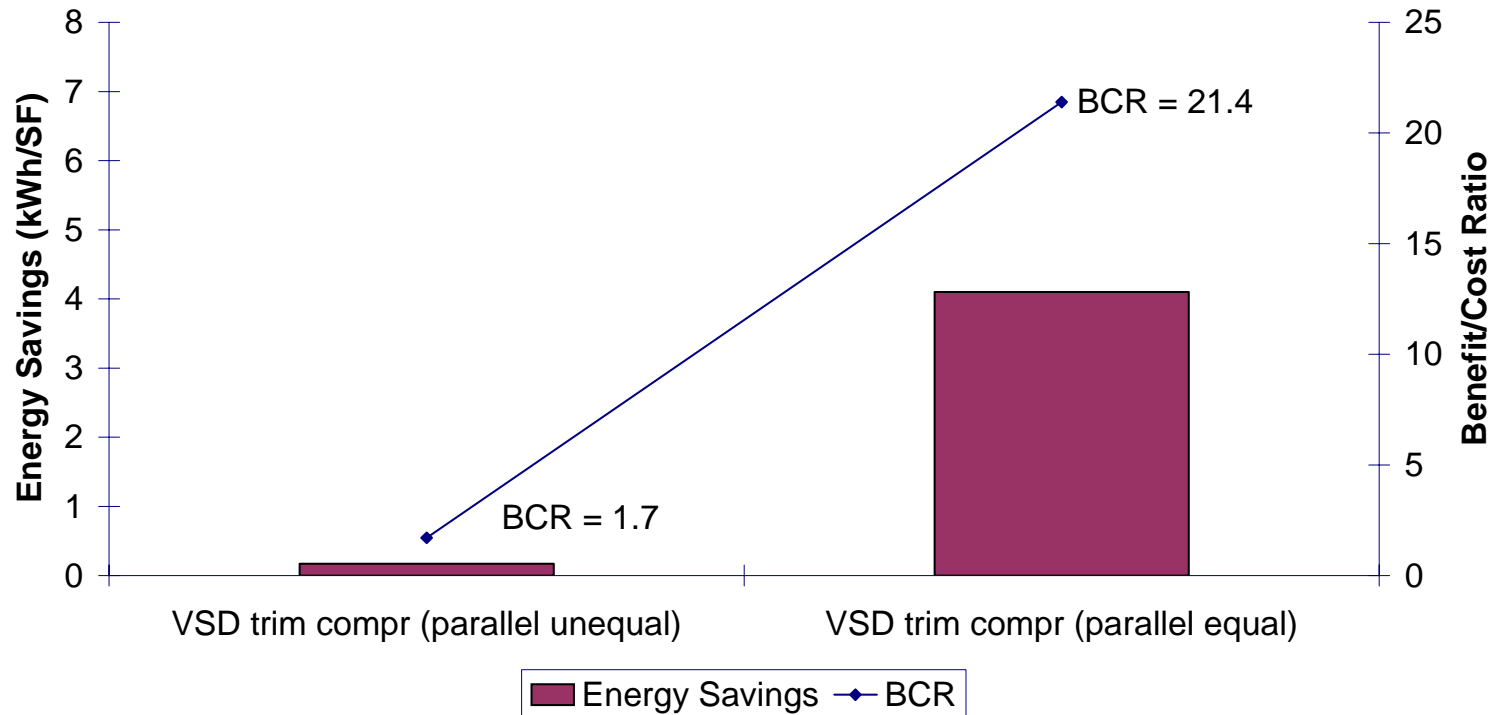
VSD Compressor Analysis

- Used 15 year TDV to value energy cost savings
- Looked at VSD on 3 compressor parallel equal line
- Looked at VSD also on smallest compressor in 3 compressor parallel unequal line
- VSD costs from 2005 DEER Measure Cost Study @ \$171/ton



VSD Trim Compressor Energy Savings and Cost Effectiveness

VSD Compressor Energy Savings and Cost effectiveness



Evaporative Condensers



Condenser Oversizing and Floating Head Pressure

- Used 15 year TDV to value energy cost savings
- Varied design approach temperature from 25°F to 13°F
- Condenser fan and pump power improved from 330 Btu/hr-watt to 400 Btu/hr-watt
- Minimum condensing temperature dropped from 85°F to 70°F

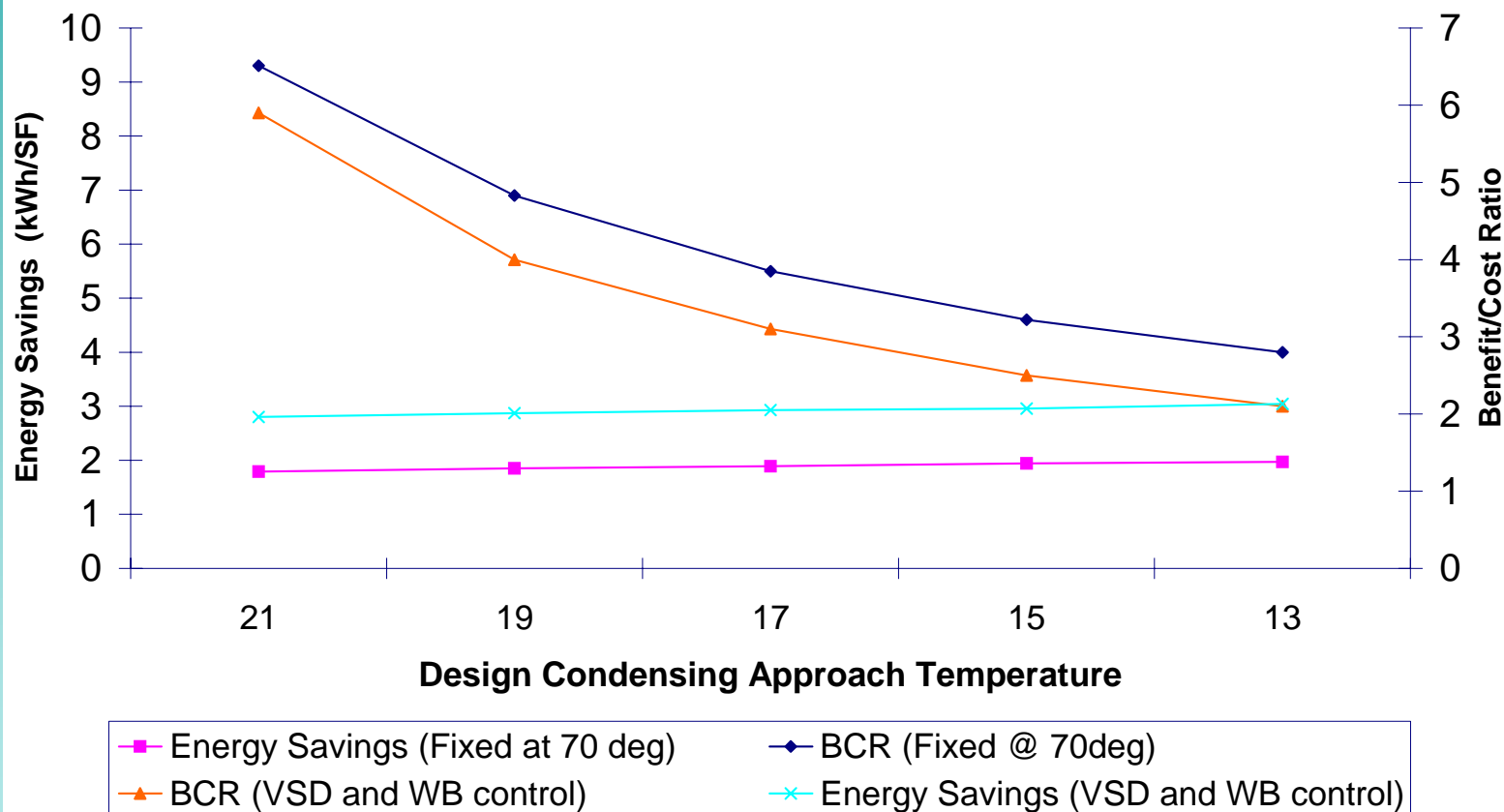


Oversized Evaporative Condenser and Floating Head Pressure

- Scenarios presented:
 - Fixed condensing temperature
 - 9°F wetbulb offset with VSD
- 2005 DEER Measure Cost Study used
 - \$88 per ton @ 5°F reduction
 - \$203 per ton @ 5°F reduction with VSD and wetbulb control
 - Scaled based on reduction modeled



Oversized Condenser Energy Savings and Cost Effectiveness



Shell Insulation



Freezer Floor Insulation

Insulated Panels



Insulation Energy And Economic Analysis

- Used 30 year “Time Dependent Valuation” costs
- Insulation incremental cost (R.S. Means)
 - Roof insulation
 - Polyisocyanurate @ R-7.1 per inch
 - \$0.25 per SF – in.
 - Wall insulation
 - \$0.63 per SF – in.
 - Polyurethane @ R-5 per inch
 - Floor insulation
 - Extruded polystyrene @ R-5 per inch
 - \$0.32 per SF – in.



Insulation Analysis

Shell Component	Common Practice	ASHRAE Recommendation	CASE Recommendation	Benefit/Cost	
				Coastal (CZ 3)	Central Valley (CZ 13)
Freezer Ceiling	R-46	R-45 to R-50	R-49	3.7	4.3
Freezer Wall	R-32	R-35 to R-40	R-40	1.9	2.2
Freezer Floor	R-30	R-27 to R-32	R-30	4.8	5.0
Cooler Ceiling	R-24 to R-40	R-30 to R-35	R-35	1.1	2.0
Cooler Walls	R-25	R-25	R-25	0.6	1.1

Note: BCR varies with refrigeration plant efficiency – efficient plant used



Under Floor Heat

- Energy consumption for under floor heat
 - 2.0 Btu/hr-SF (-20°F freezer, R-30 insulation)
 - 0.6 W/SF (5.2 kWh/SF-yr)
 - 15 yr NPV TDV electricity costs for electric heat = \$15.43 per SF
- Costs taken from R.S. Means
 - \$2.26 per SF for glycol system
 - \$2.04 per SF for electric system
- Benefit / Cost Ratio = 70+

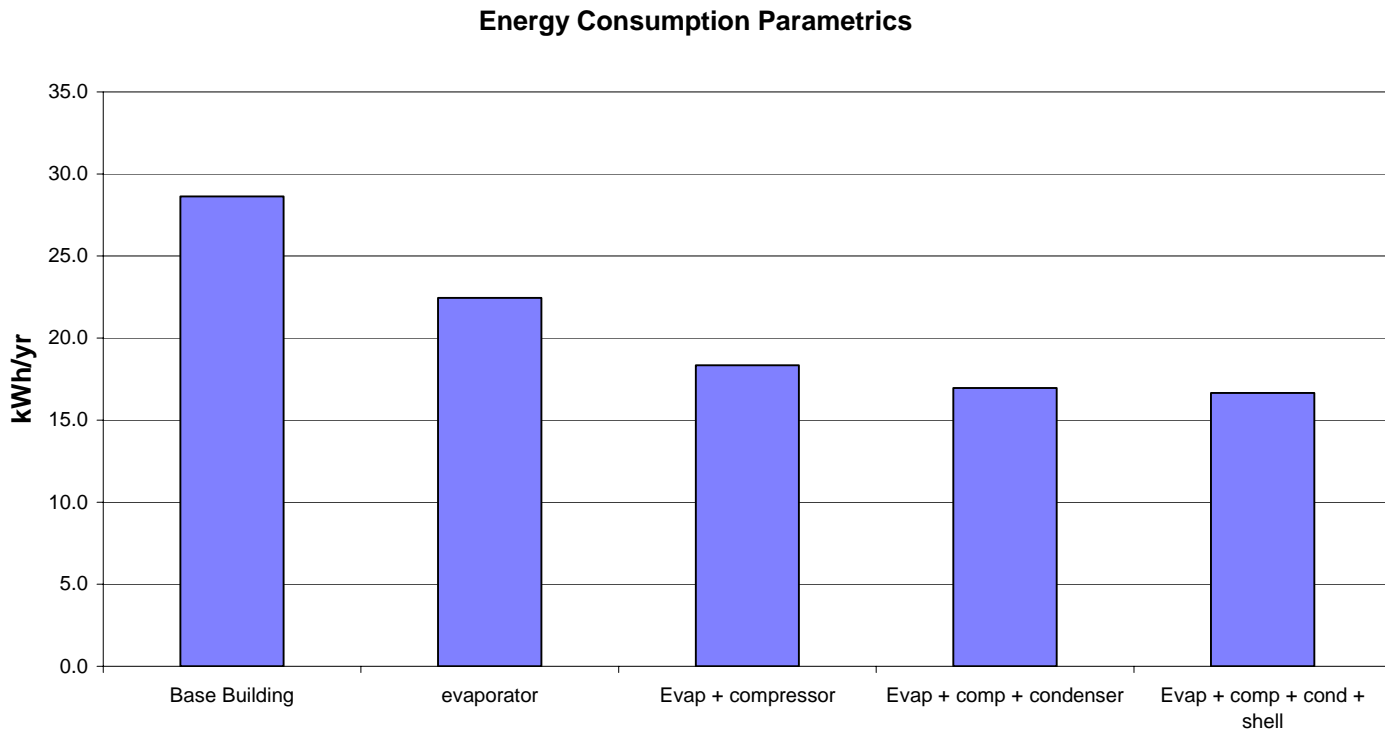


Temperature Terminate Defrost

- Defrost needs vary by location within the facility, time of day and season
- Time on, time terminate defrost controls may be set for “worse case” conditions
- Time on, temperature terminate controls are standard practice
- Require additional temperature sensor at evaporator
- Case studies cited quick paybacks (< 1 year)



Energy Consumption Parametrics



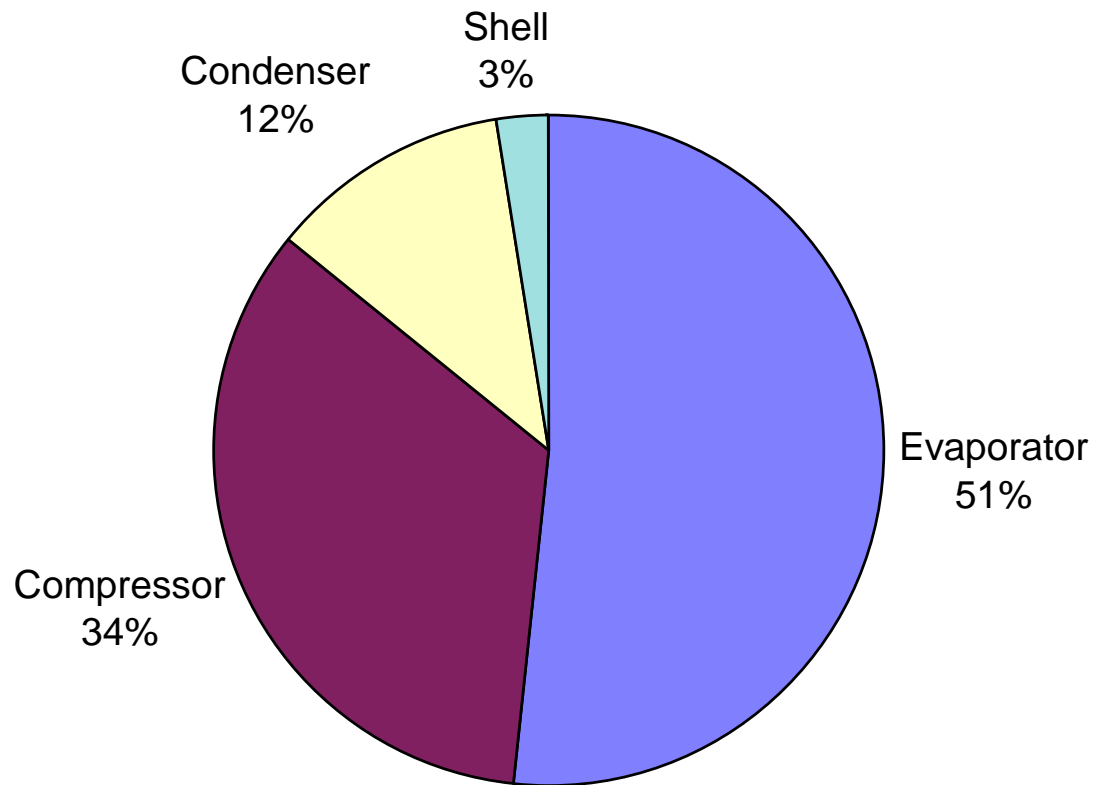
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Overall Energy Savings Analysis

- Energy savings of about 12 kWh/SF and non-coincident peak demand savings of 1.4 W/SF
- Represents about 40% of annual consumption of prototype model
- Cost effective



Energy Savings Breakdown



Code Change Proposal

- Mandatory Measures
 - Lack of ACM for refrigerated warehouses precludes prescriptive approach
- New section in Standards
 - Section 120 – Mandatory Requirements for Refrigerated Warehouses
- Applies to freezers and coolers > 3000 SF



Proposed Code Provisions - Evaporators

- Require VSDs on evaporator fan motors
- Limits on evaporator fan motor power of 0.15 W/cfm
- Limit electric defrost
 - Exception based on system size
- Require temperature termination on defrost controls



Proposed Code Provisions - Compressors

- Require compressors and accessories supplied by manufacturers to operate at 70°F condensing
- Require VSD on at least one compressor per suction group



Proposed Code Provisions - Lighting

- Use same lighting provisions as for non-refrigerated warehouses
 - Max lighting power of 0.6 W/SF
 - Require bi-level lighting controls in storage spaces



Proposed Code Provisions - Condensers

- Require evaporative condensers on all ammonia systems
- Limits on condenser wetbulb approach temperature
 - 20°F at design conditions
- Limits on condenser fan and pump power
 - 400 Btu/hr-watt
- Require floating head pressure control to 70°F
- VSD on evaporative condenser fans controlled by wetbulb or load



Proposed Code Provisions – Insulation

- Minimum R-values for freezers
 - R-40 Wall
 - R-49 Ceiling
 - R-30 Floor
- Minimum R-values for coolers
 - R-25 Wall
 - R-35 Ceiling
- Limit on electric resistance under floor heating
 - Exception based on facility size
 - Resistance heat must be controlled off during summer on-peak periods



Discussion



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Information and Contacts:

- Full CASE report available for download:

www.energy.ca.gov/title24/2008standards/documents/2006-02-22+23_workshop/2006-02-15_DRAFT_REP_PG&E.PDF

- Please send written comments to:

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- Thank you very much!!

