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Innovation for Food Retail: The 50% Advanced Energy Design Guide for Grocery Stores

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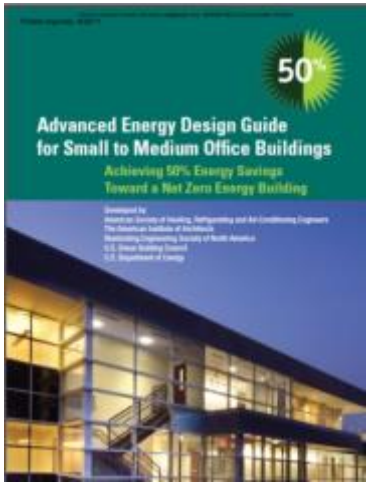
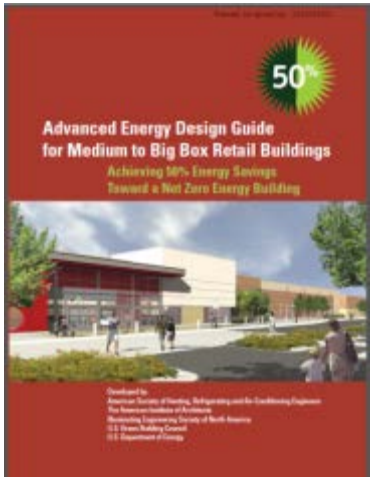
Overview and Process

Paul A. Torcellini, Ph.D., P.E.

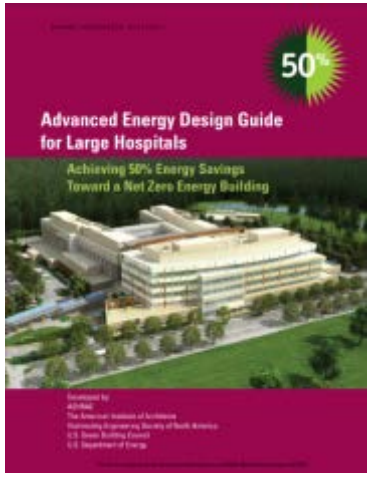
50% Guides



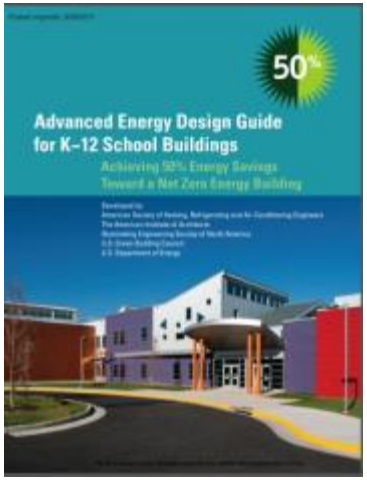
Office



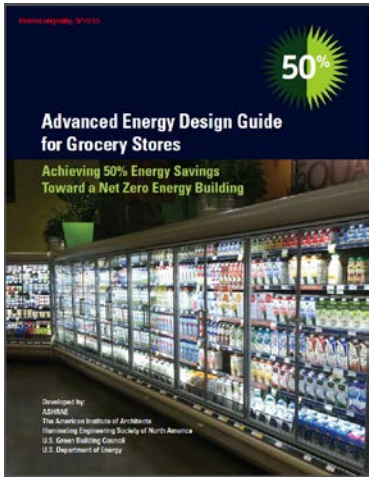
Medium, Big Box Retail



Hospitals



K12 Schools



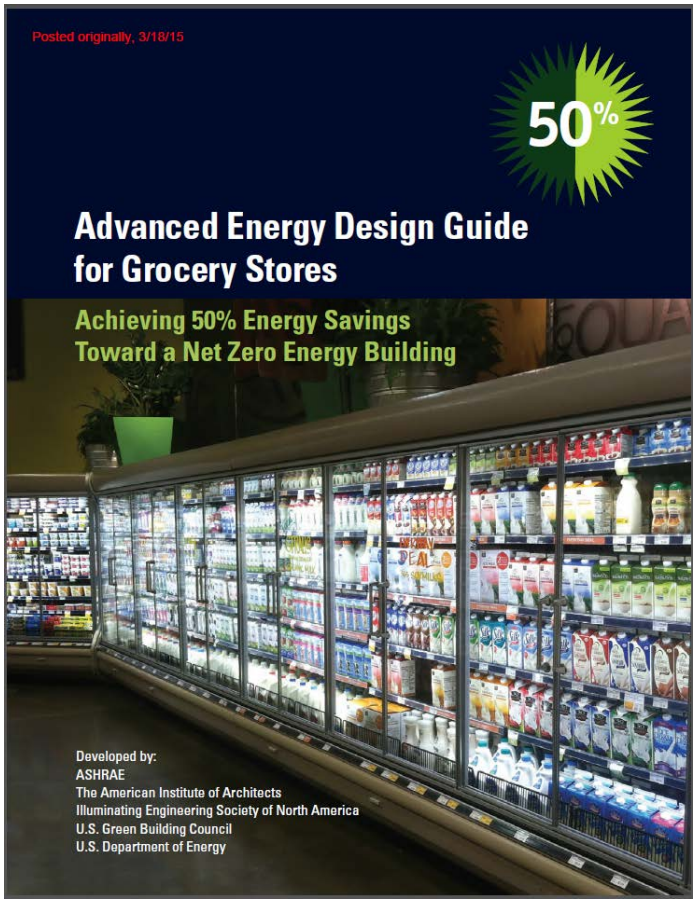
Grocery

- Five 50% Guides published and available for free download
- Circulation of 50% Series Guides is 150,000+ copies
- 50% energy savings over 90.1-2004

Integration

Developed by:

- ASHRAE
- American Institute of Architects
- Illuminating Engineering Society
- U.S. Green Building Council
- U.S. Department of Energy



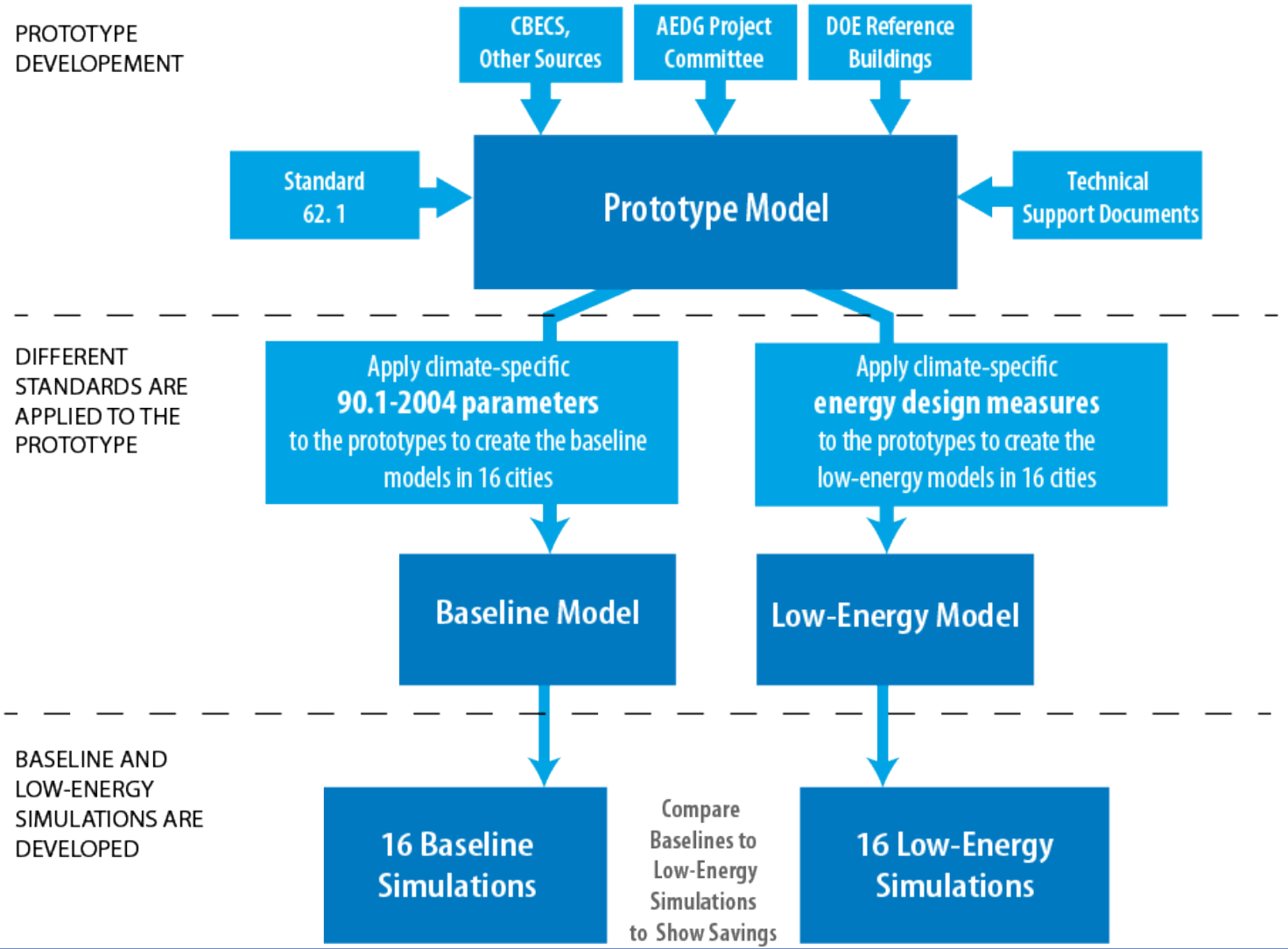
Project Committee

- **Paul Torcellini**, Chair, National Renewable Energy Laboratory
- **Bernie Bauer**, IES Represenative, Integrated Lighting Concepts
- **Aaron Daly**, Member-at-Large, Whole Foods Market
- **Don Fisher**, Member-at-Large, PG&E Food Service Technology Center
- **Michael Lane**, IES Representative, Puget Sound Energy
- **Ken Lowney**, AIA Representative, Lowney Architecture
- **Merle McBride**, ASHRAE Representative, Owens Corning
- **Jim McClendon**, ASHRAE Representative, Walmart Stores, Inc.
- **Daniel Nall**, AIA/USGBC Representative, Syska Hennessy Group
- **Caleb Nelson**, Member-at-Large Refrigeration, CTA
- **Doug Scott**, Member-at-Large Refrigeration, VaCom Technologies
- **Eric Bonnema**, Analysis Support, National Renewable Energy Laboratory
- **Lilas Pratt**, Staff Liaison, ASHRAE

AEDG Development Process

- Steering Committee representing partnering organizations
- Project committee of experts write guide
- Building energy simulation to evaluate energy efficiency measures by the National Renewable Energy Laboratory
- Open peer review at 65% and 90% drafts

Evaluation Approach



16 Climate Zones: 1A, 2A, 2B, 3A, 3B: CA, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 6A, 6B, 7, 8

Energy Modeling in 16 Cities Representing Each Climate Zone

AEDG Document Content

AEDG presents:

- "A Way Not The Only Way…" to achieve the desired savings.
- A tutorial on the elements of Integrated Design for energy efficiency.
- A prescriptive path by climate zone to achieve desired savings
- How-to tips and caveats for selected energy conservation measures

AEDG Table of Contents

Chapter 1 – Introduction
- How to use this document

Chapter 2 – Integrated Design Process
- How the design process changes in order to achieve 50% energy savings

Chapter 3 – Design Concepts and Practices
- Overview of the technical approaches to achieving 50% savings
- Subsystem integration

Chapter 4 – Design Strategies and Recommendations by Climate Zone
- Specific technical requirements to meet the 50% goal

Chapter 5 – How To Implement Recommendations
- Specific technical guidance for implementation of recommendations, including technical resources and warnings

Appendices
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- International Climatic Zone Definitions

Chapter 5 – How to Tips

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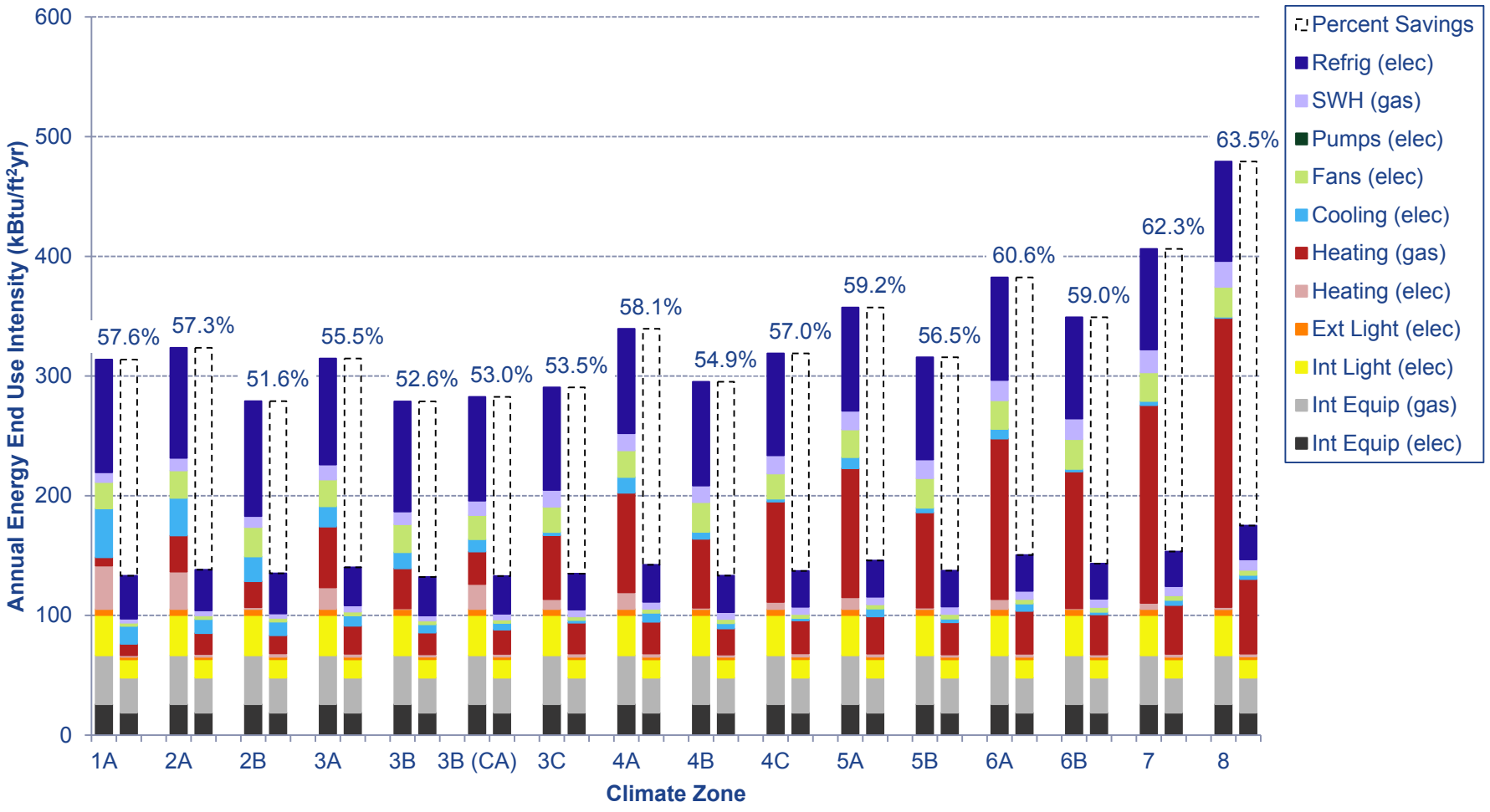
- Electric Lighting
- Plug Loads
- Kitchen Equipment
- Refrigeration Equipment
- Service Water Heating
- HVAC Systems and Equipment
- Quality Assurance
- Bonus Savings
  - Including renewable energy

AEDG Savings by Climate Zone



Recommendation Tables

Climate Zone 4 Recommendation Table for Grocery Stores

	Item	Component	Recommendation	How-to Tips	✓
Envelope	Roofs	Insulation entirely above deck	R-30.0 c.i.	EN1, 19–21	
		Metal building	R-19.0 + R-11.0 Ls	EN2, 19–21	
		SRI	No recommendation*	None	
	Walls	Mass (HC > 7 Btu/ft^2)	R-9.5 c.i.	EN4, 19–21	
		Metal building	R-0.0 + R-15.8 c.i.	EN5, 19–21	
		Steel framed	R-13.0 + R-7.5 c.i.	EN6, 19–21	
	Floors	Mass	R-14.6 c.i.	EN7, 19–21	
		Steel framed	R-30.0	EN8, 19–21	
	Slabs	Unheated	R-15 for 24 in.	EN9, 11, 19–21	
		Heated	R-20 for 24 in.	EN10–11, 19–21	
		Freezer box floors	See Table 5-2	EN12	
	Doors	Swinging	U-0.50	EN13, 20	
		Nonswinging	U-0.16	En14, 20	
		Vehicular/dock infiltration—door closed	0.28 cfm/ft^2 of door area	EN15, 20	
		Vehicular/dock infiltration—door open, truck in place	Weather seals for dock, levelers, trailer hinges	EN16, 20	
	Vestibules	All building entrances	Yes	EN17, 20	
	Continuous	Continuous air barrier	Entire building envelope	EN18	
				EN22–23, 26–28	
				EN23, 26–28	
				EN29	
	Daylighting	Skylights or rooftop monitors	d per Standard 90.1 when sales floor ceiling height > 15 ft and area is ≥ 2500 ft^2	DL1–10	
		Daylight area	≥ 50% of the sales floor	DL1–10	
		Skylight to daylight area	Minimum = 3%, maximum = 5%	DL3	
		VT	Skylight VT ≥ 0.40	DL3	
		Skylight SHGC	0.35	EN25–27	
		Skylight thermal transmittance	U-0.50		
		Effective aperture	Skylight effe		
		Glazing material/diffuser	Measured h according to		
		Controls			

Location and System

How-to Tips

Recommendation

Case Studies

- Actual projects—actual savings numbers

Whole Foods Market—A Case Study

The Whole Foods Market store in Raleigh, North Carolina (Climate Zone 4A), opened in March 2011. The 40,000 ft^2 single-story, stand-alone store includes fresh and packaged food items, general merchandise, an in-house bakery, a deli, and food preparation areas.

The store was the first constructed under Whole Foods Market's goal of reducing annual energy consumption by 50% as part of DOE's Commercial Buildings Partnership program (EERE 2015a). The criteria used to evaluate energy-efficient measures for the project include payback period (≤ 5 years), tax incentives, and utility rebates, as well as costs for capital, installation, O&M, and energy.

Interaction between the building's systems was a key design consideration. The design team estimated energy savings for combined packages of energy efficiency measures rather than for individual measures. This allowed for the consideration of individual energy efficiency measures that may have been deemed too expensive had they been evaluated individually as well as for the determination of savings for the entire system and not just for components.

Refrigeration

Refrigeration is a major portion of the energy use in a supermarket. Strategies employed to reduce energy usage of the refrigeration systems include the following:

- Case doors are included on medium-temperature dairy, deli, and packaged produce cases to reduce load.
- Night curtains are used on open medium-temperature cases to reduce load during unoccupied hours.
- Anti-sweat door heaters were installed to minimize condensation. A lower sales floor dew point is maintained in conjunction with the anti-sweat control strategies for the refrigerated case doors.
- LED lights are used instead of T8 fluorescents in all low-temperature and medium-temperature refrigerated cases and walk-in freezers to reduce both lighting power usage and additional load from lamp and ballast heat.
- Electronically commutated (high-efficiency) evaporator fan motors were installed in refrigerated cases.

Reducing Plug Loads

- Evaluate the plug loads

- Purchase Energy Star
- Auto-off Product
- Controls
  - Motion
  - Time-out
  - Load Sensing
  - Manual Switch

Plug Load	Purchase ENERGY STAR Product	Motion-Activated Switch or Strip	Time-Out/Vacancy-Based Switch or Strip	Load Sensing to Master	Time Clock on Store Hours	Manual Switch	Specify PRODUCT with Auto OFF	No Control Strategy Available	Comments
way radio charging station							x		
mpressor, cake decorations			x				x		
ry charger, single battery							x		
ry charging station, ble printer/label machine							x		
ry charging station, ess scanning tool							x		
ry charging station, jack or forklift							x		
rage refrigerator	x				x				Set thermostat to 39°
l pressure monitor					x				
k room refrigerator	x								Maximum one 18 ft³ p employees; use as sn as possible
amp					x				
ger for floor washer								x	
e grinder station					x				
Coffee maker, break room					x		x		Auto OFF is a standard feature on many make
Coin exchange customer kiosk					x				
Computer monitor, checkout area				x		x			Control with "lane occ switch

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Bibliography

- www.ashrae.org/freeaedg
- https://buildingdata.energy.gov/cbrd/resource/1906
- Buildingdata.energy.gov/cbrd (search for AEDG)
  - Technical support documents
  - Actual models used
  - Links to the downloads
- Paul.Torcellini@nrel.gov

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Envelope

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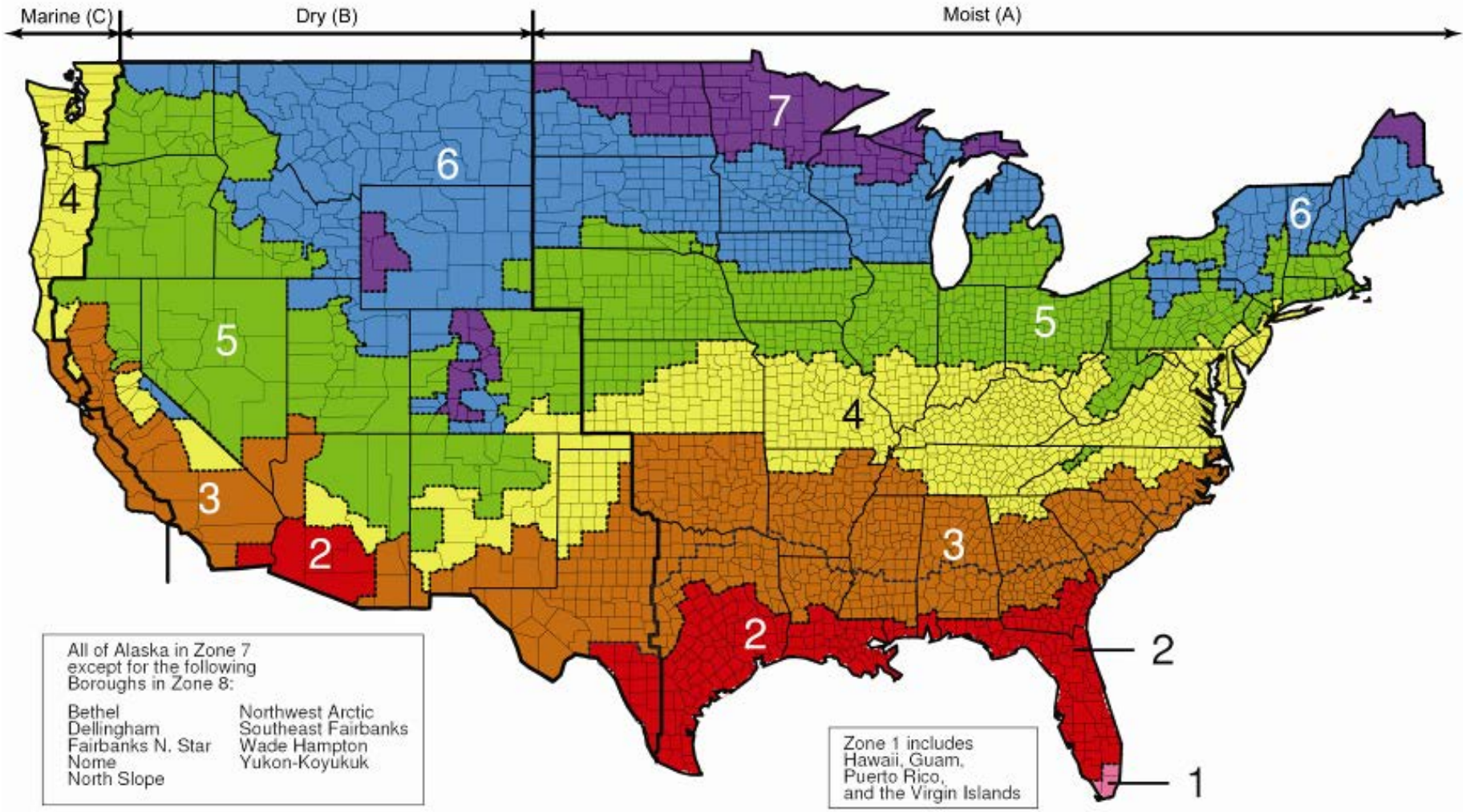
Agenda - Envelope

- Climate Zones
- Prototype Building Model
- Envelope Criteria
- UA Reductions of the Envelope
- Freezer Box Curb Details
- Vestibule Configurations
- Windows and Overhangs
- Thermal Bridges
- Envelope Thermal Performance Factors

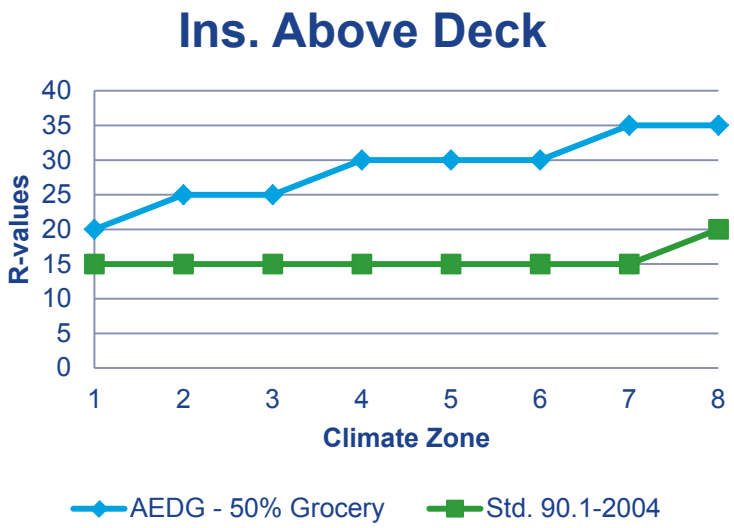
Climate Zones



Prototype Building Model

- Floor Area = 45,000 ft^2 (173 ft x 260 ft)
- Wall Height = 20 ft
- WWR = 8.1%, 1,400 ft^2
- Insulation Above Deck
- Mass Walls
- Unheated Slab-on-Grade

Envelope - Roofs

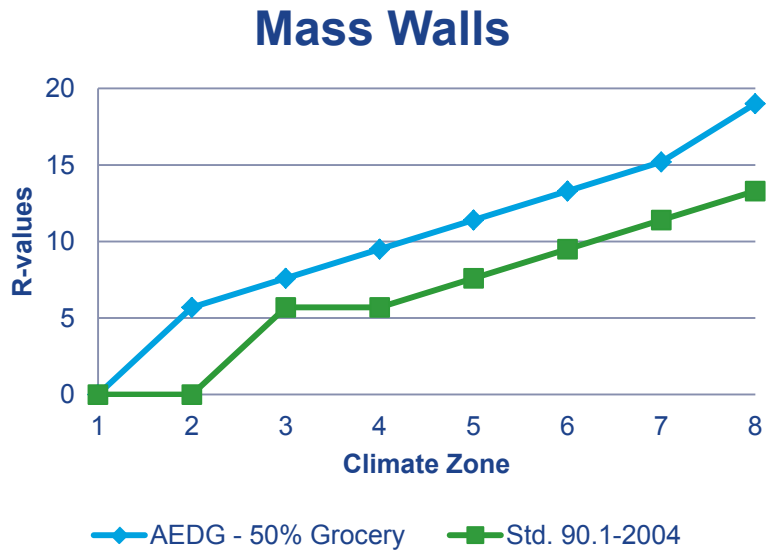


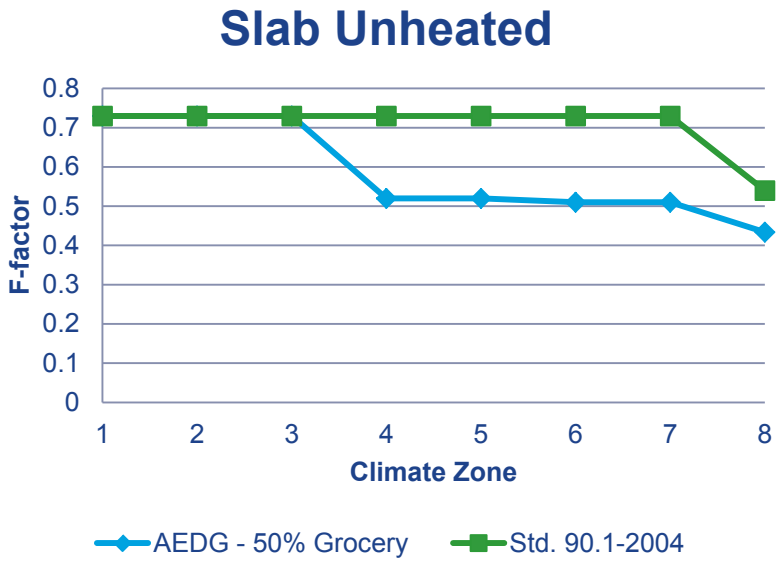
- Solar Reflective Index = 78

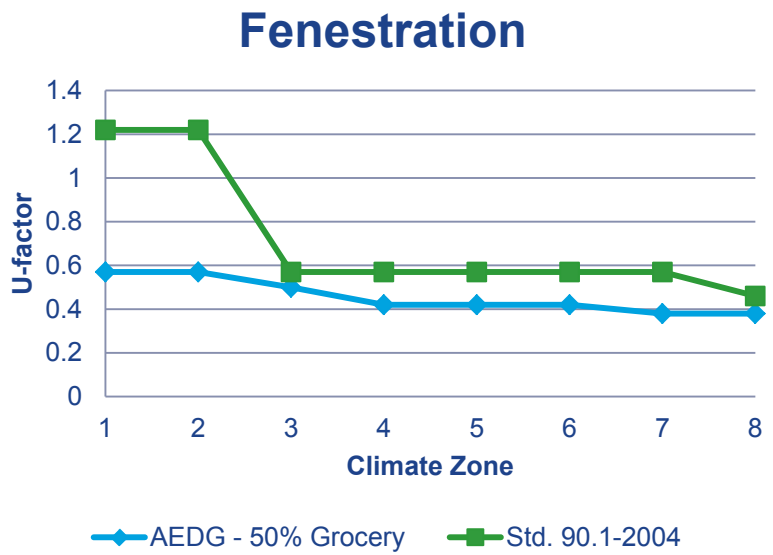
Table 5-1 Examples of Cool Roofs

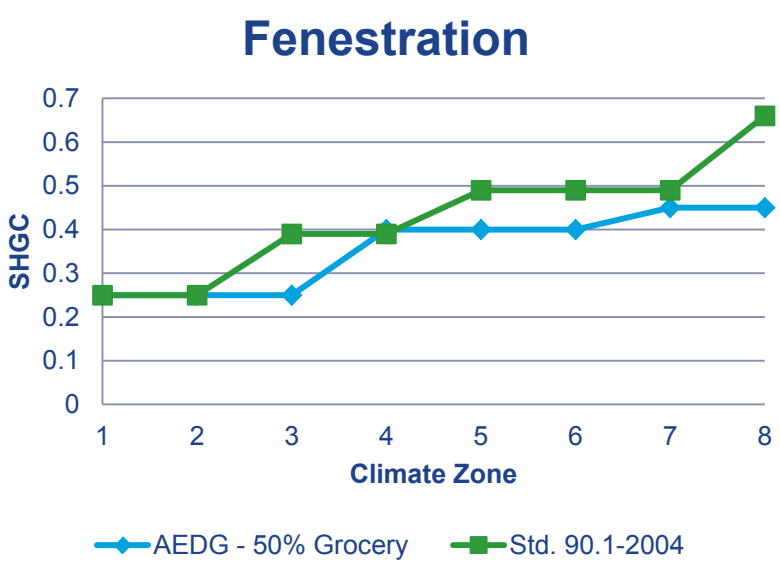
Category	Product	Reflectance	Emissivity	SRI
Single ply	White polyvinyl chloride (PVC)	0.86	0.86	107
	White chlorinated polyethylene (CPE)	0.86	0.88	108
	White chlorosulfonated polyethylene (CPSE)	0.85	0.87	106
	White thermoplastic polyolefin (TSO)	0.77	0.87	95
Liquid applied	White elastomeric, polyurethane, acrylic coating	0.71	0.86	86
	White paint (on metal or concrete)	0.71	0.85	86
Metal panels	Factory-coated white finish	0.90	0.87	113

Envelope – Walls, Slabs and Fenestration



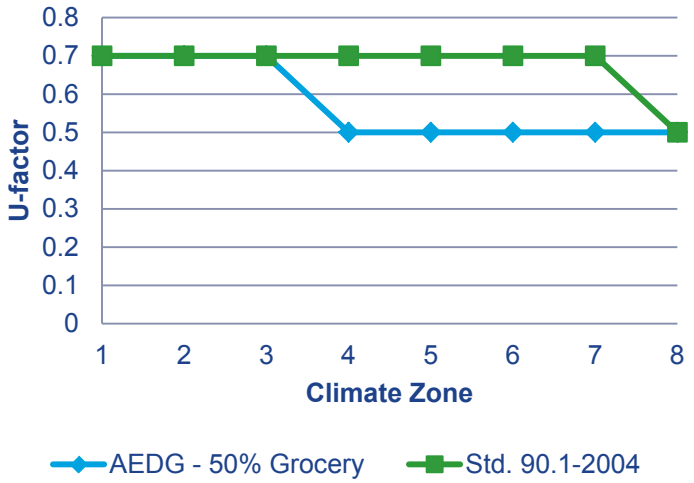




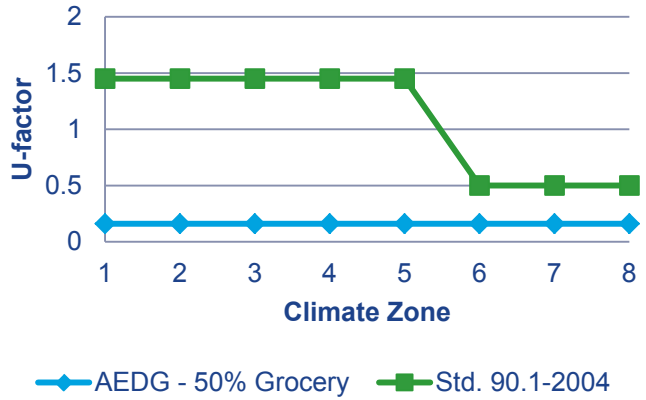


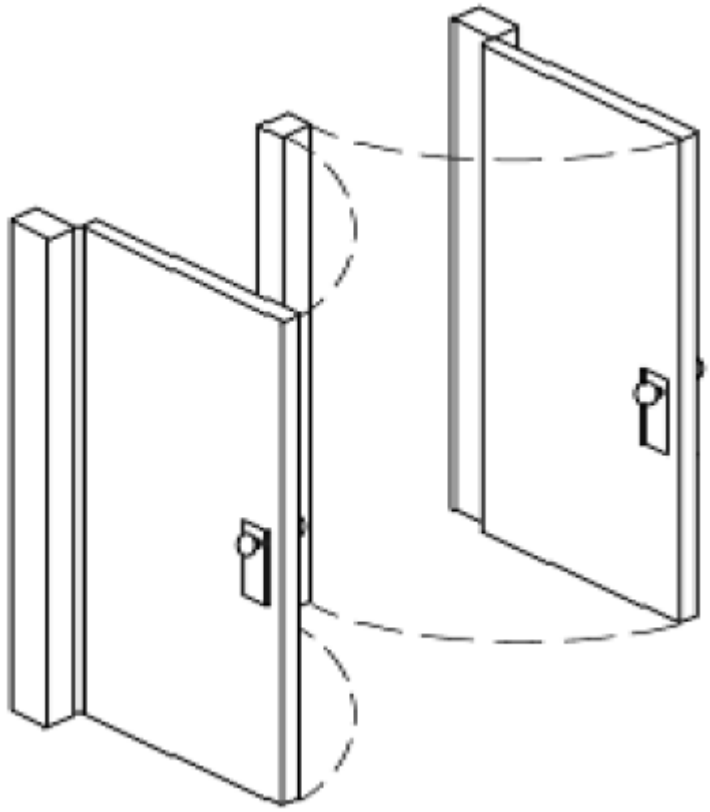
Envelope - Doors

Swinging Doors



Nonswinging Doors





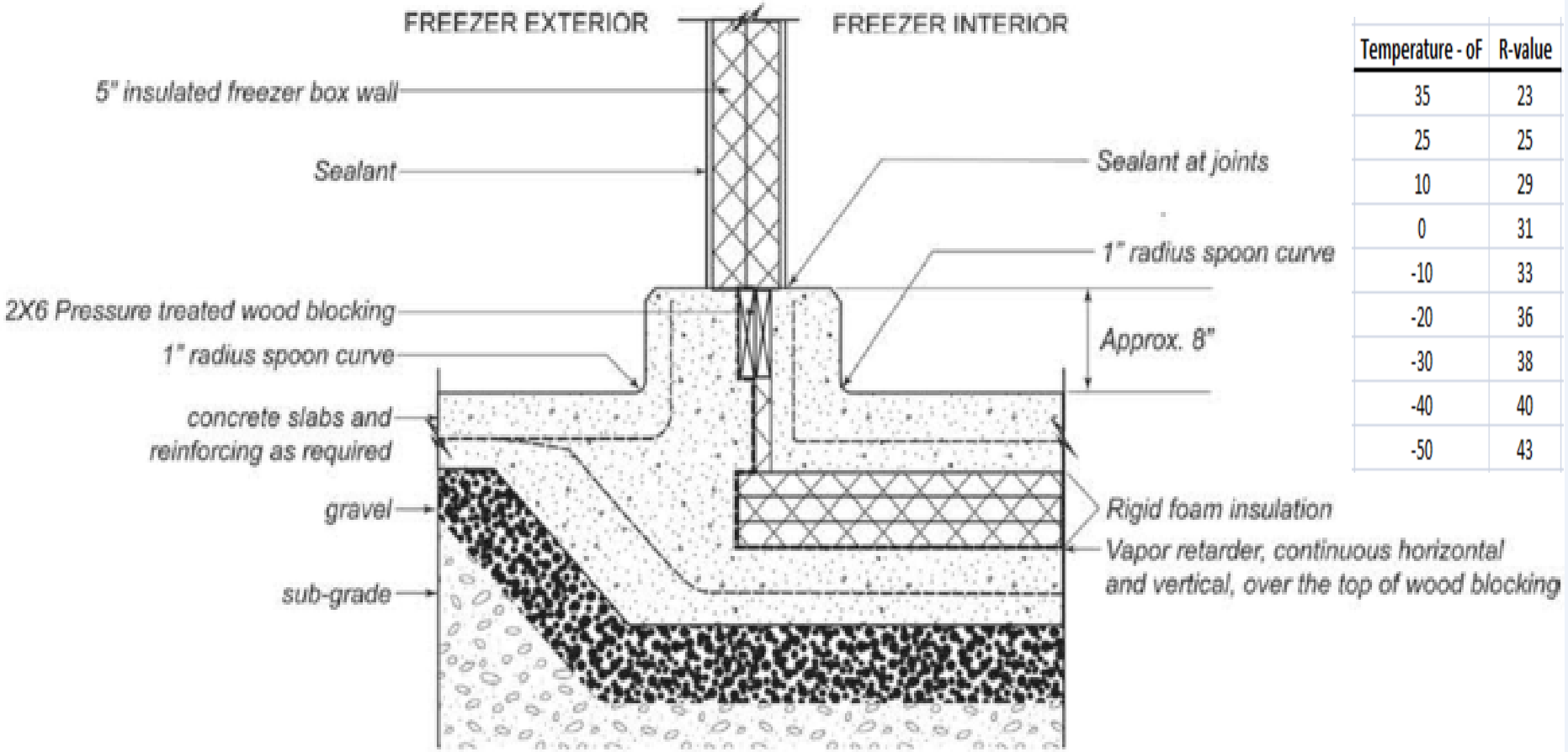
UA Reductions of the Envelope

Zone	City	90.1-2004	AEDG	Reduction-%
1A	Miami	17,371	12,825	26.2
2A	Houston	17,371	5,591	67.8
2B	Phoenix	17,371	5,591	67.8
3A	Atlanta	7,223	5,047	30.1
3B	Los Angeles	7,223	5,047	30.1
3B	Las Vegas	7,223	5,047	30.1
3C	San Francisco	7,223	5,047	30.1
4A	Baltimore	7,223	4,135	42.8
4B	Albuquerque	7,223	4,135	42.8
4C	Seattle	7,223	4,135	42.8
5A	Chicago	6,650	3,912	41.2
5B	Denver	6,650	3,912	41.2
6A	Minneapolis	6,284	3,744	40.4
6B	Helena	6,284	3,744	40.4
7	Duluth	6,021	3,365	44.1
8	Fairbanks	4,922	2,933	40.4
			AVG	**41.1**

UA Reductions - %

- Roofs
- Walls
- Unheated Slab
- Fenestration

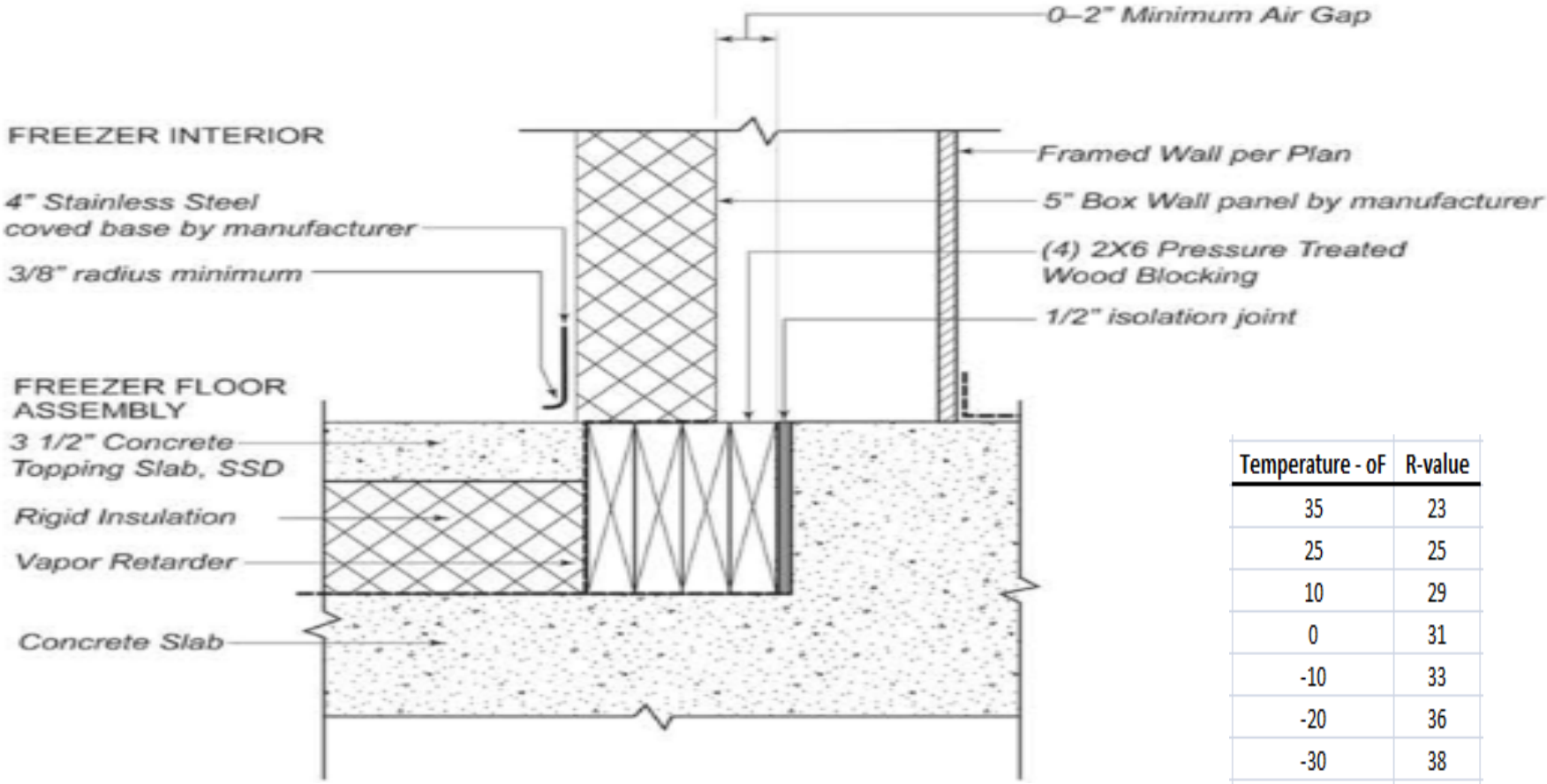
Freezer Box Curb Details



Temperature - oF	R-value
35	23
25	25
10	29
0	31
-10	33
-20	36
-30	38
-40	40
-50	43

Double Curb

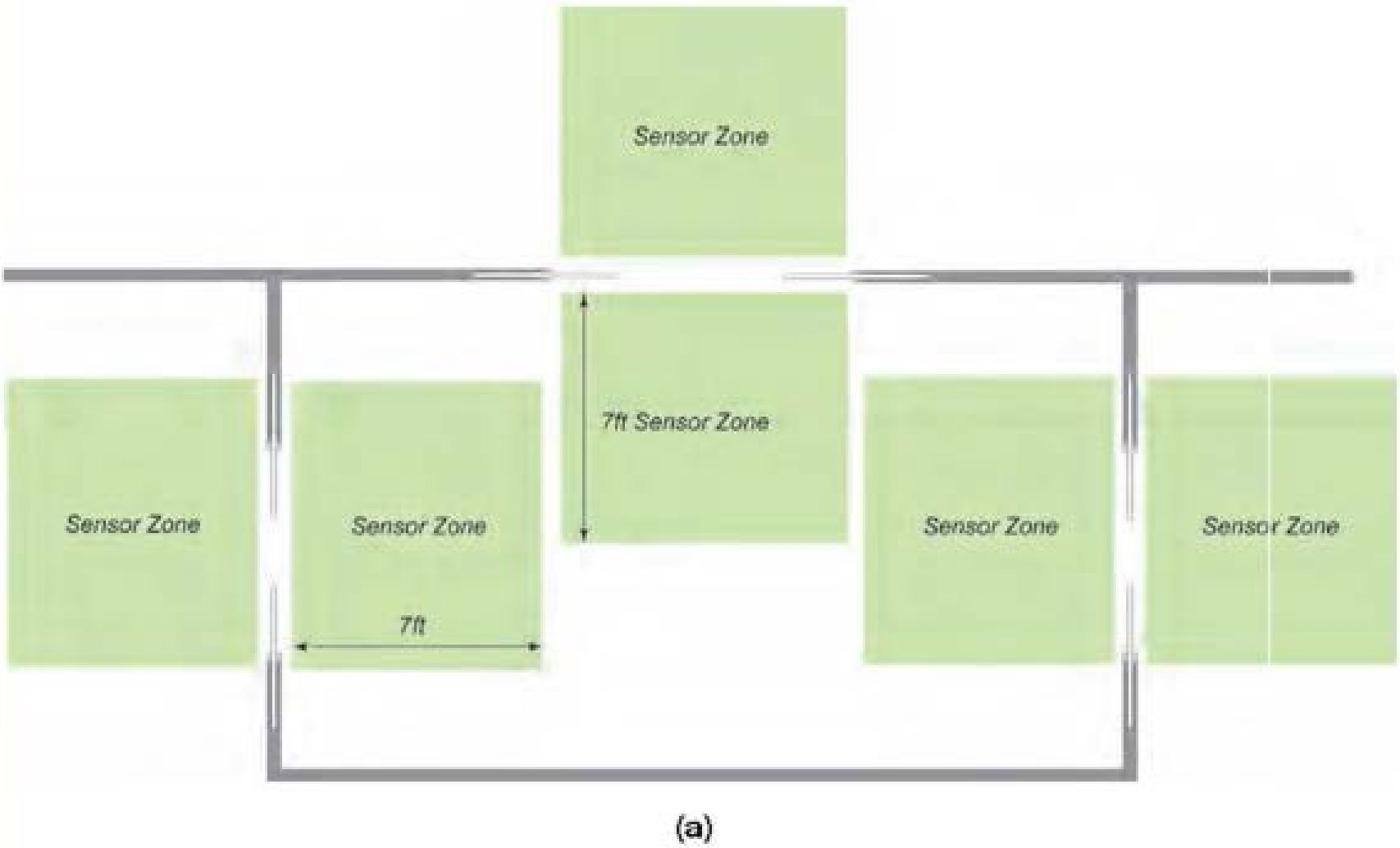
Freezer Box Curb Details



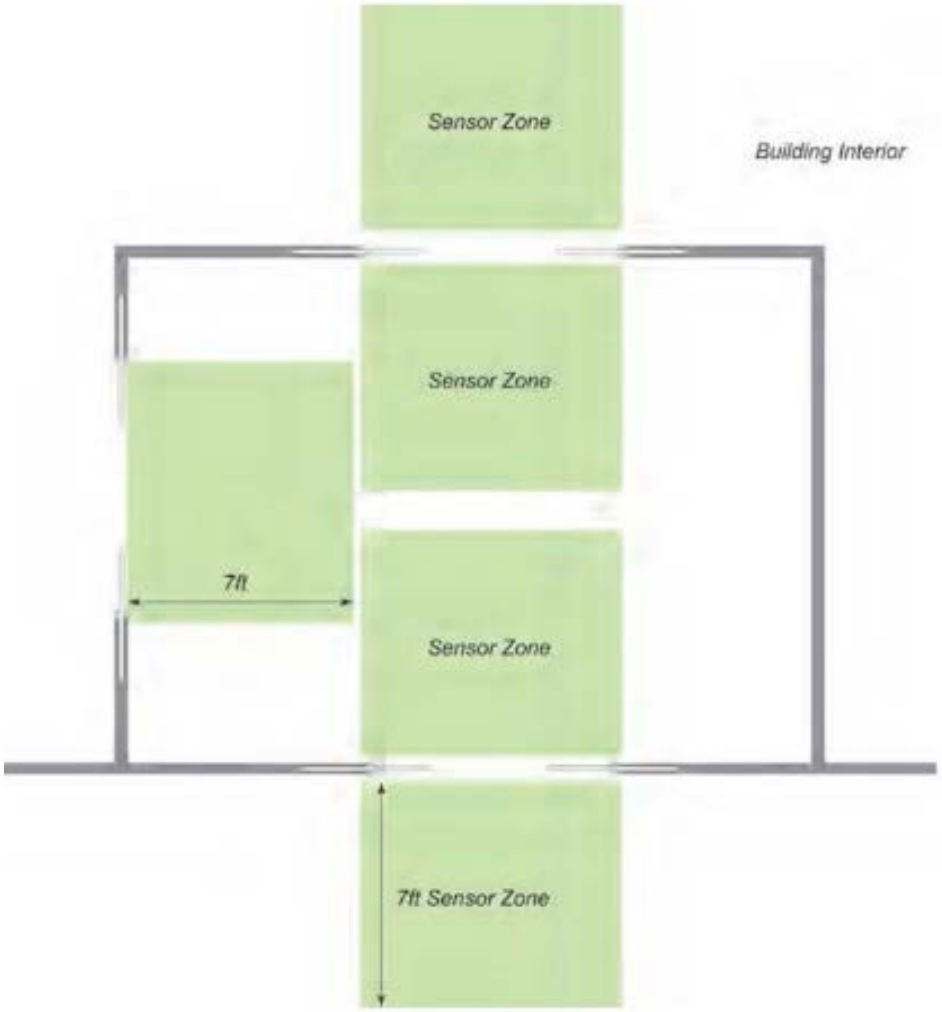
Temperature - oF	R-value
35	23
25	25
10	29
0	31
-10	33
-20	36
-30	38
-40	40
-50	43

Without Curb

Vestibule – 90° Walkway

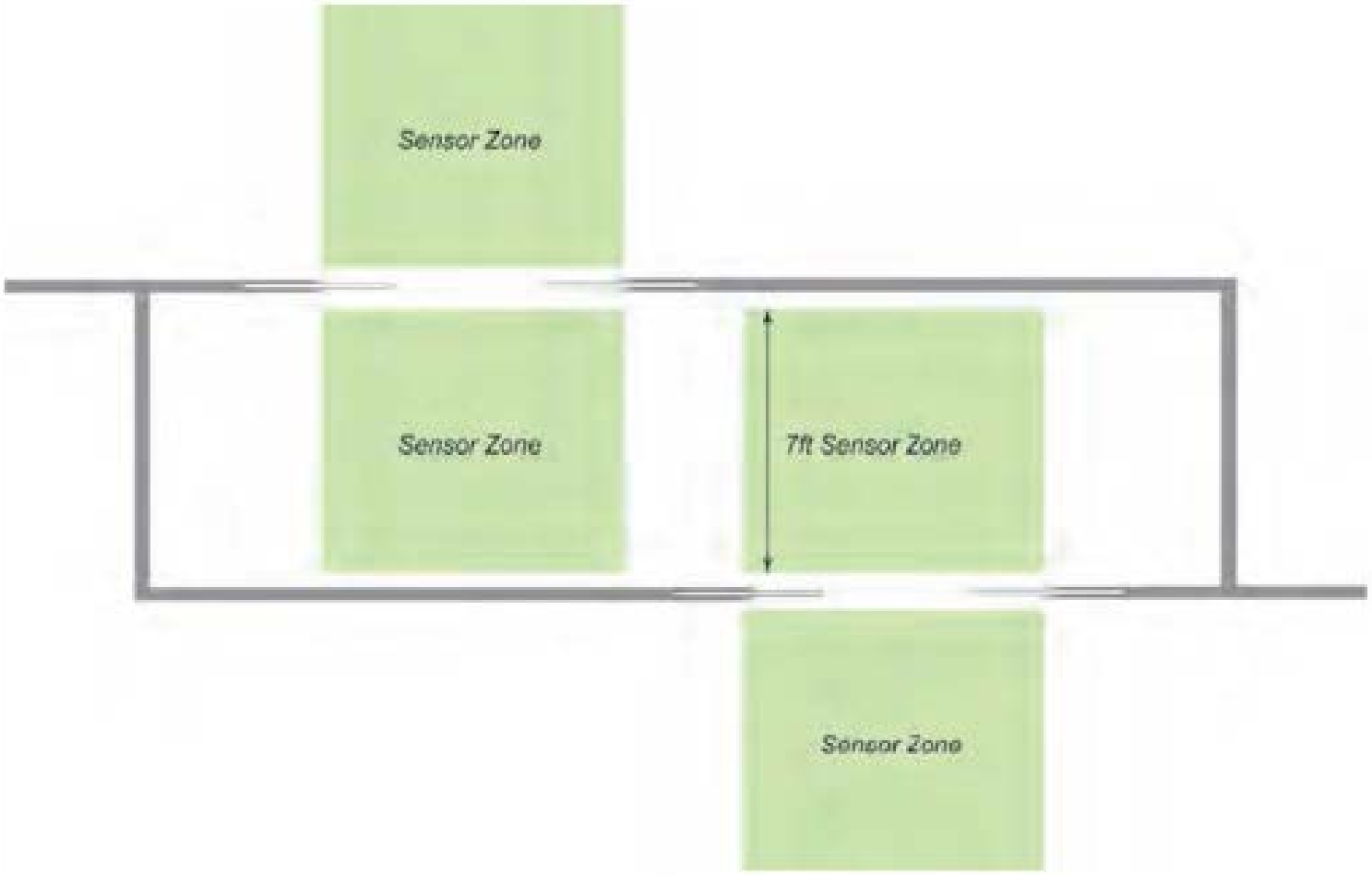


Vestibule – Straight-Through Entrance and 90° Exit



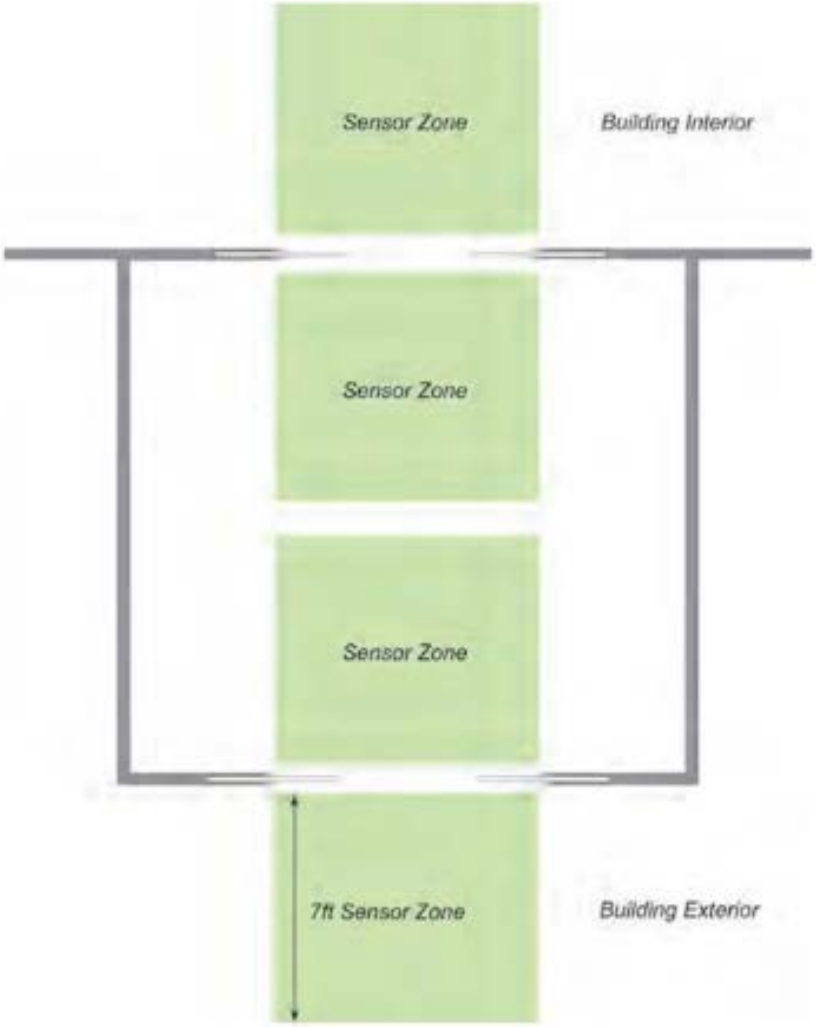
(b)

Vestibule – Offset Walkway



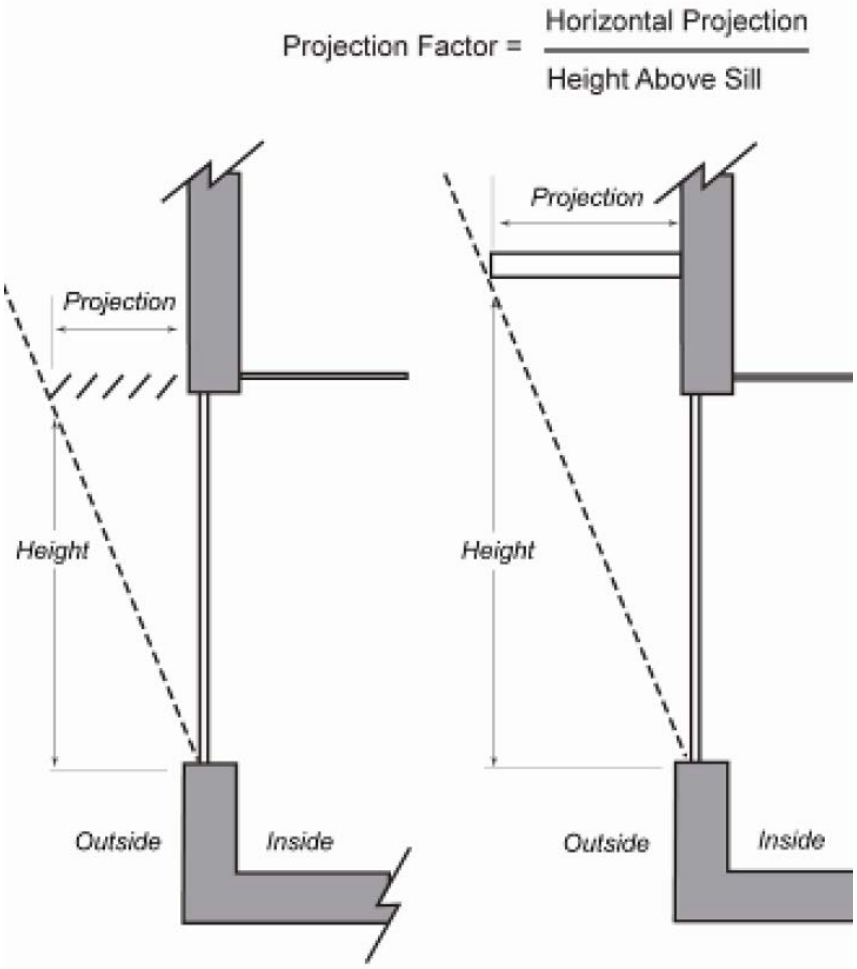
(c)

Vestibule – Straight-Through Walkway



(d)

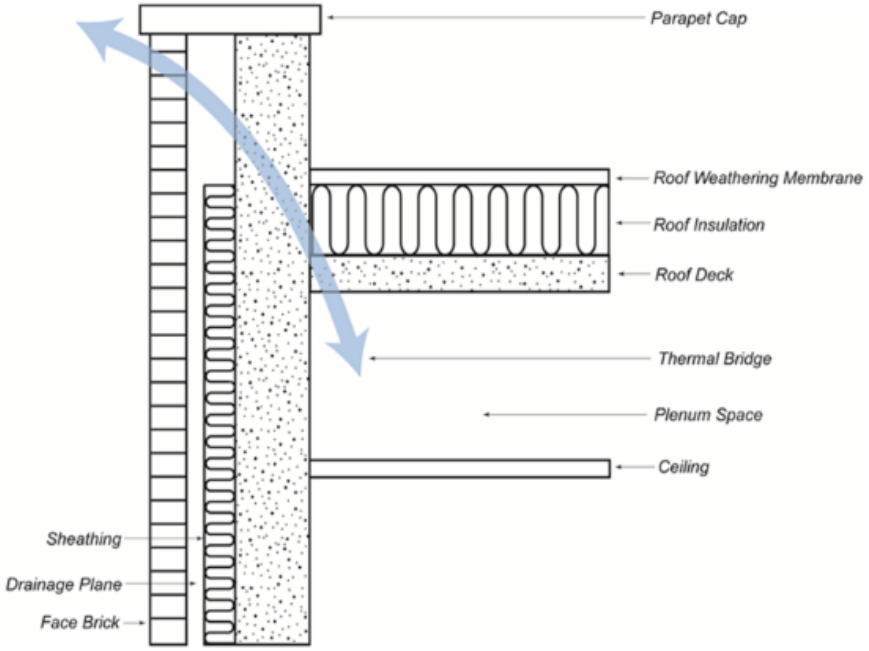
Windows with Overhangs



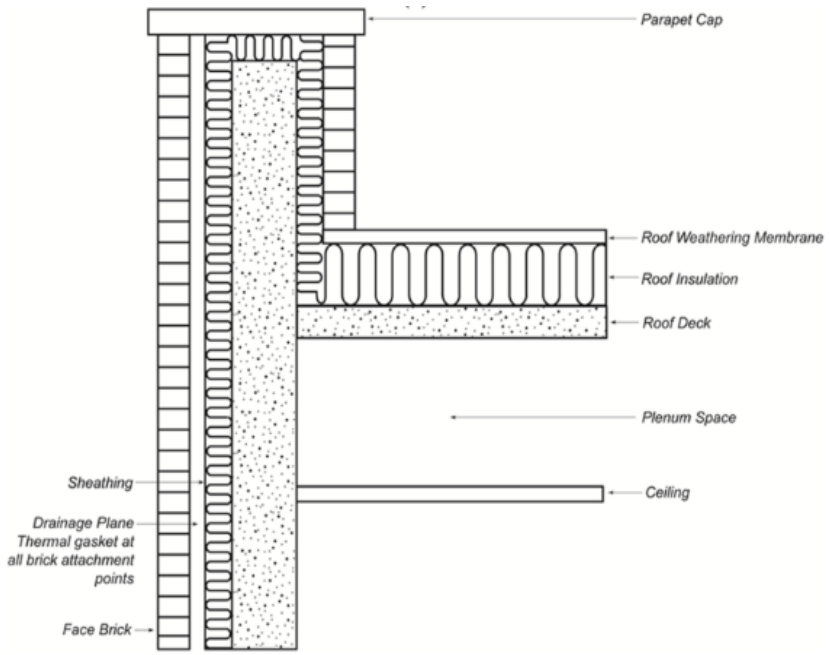
Good Design Strategies:

- Avoid glass that does not contribute to view or daylighting.
- Maximize north & south.
- Minimize east & west.
- Use overhangs to provide shading and reduce glare.

Thermal Bridges - Parapets

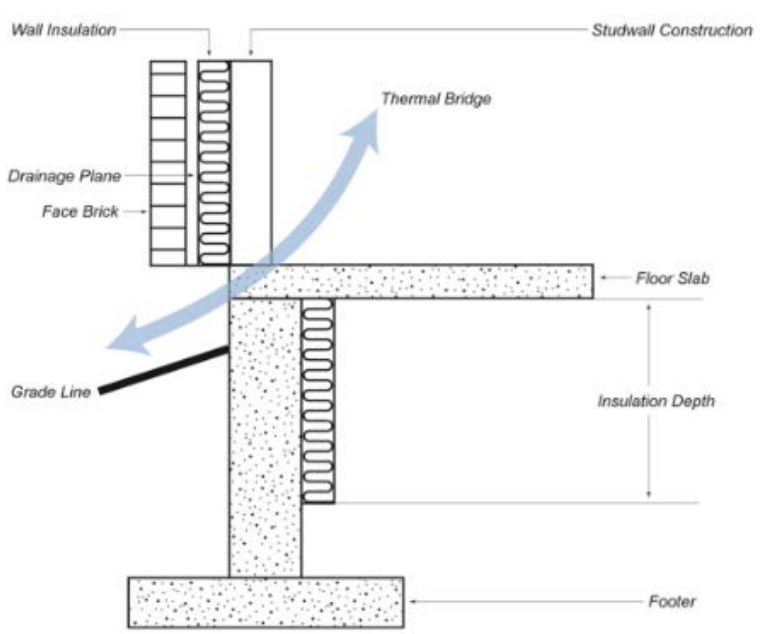


Problem



Solution

Thermal Bridges – Slab Edge



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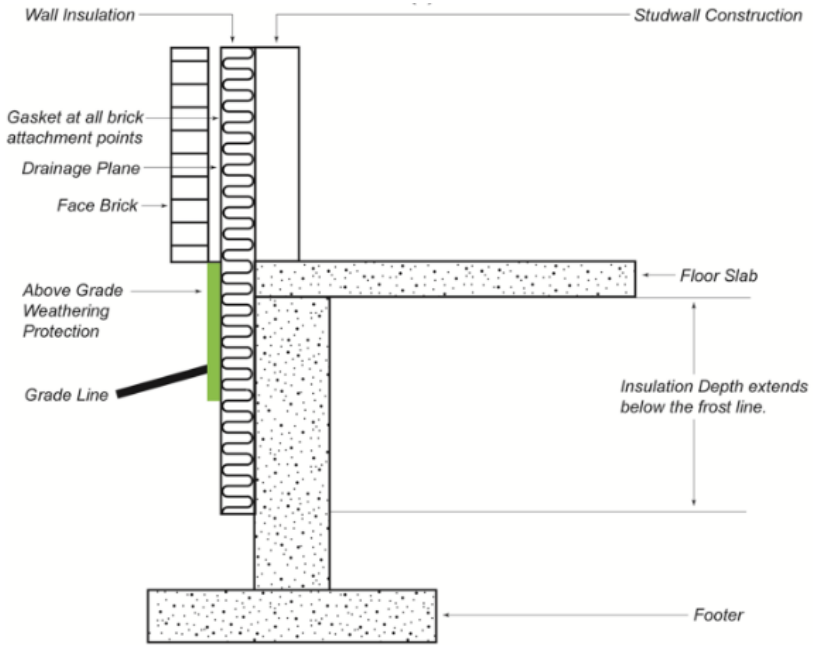
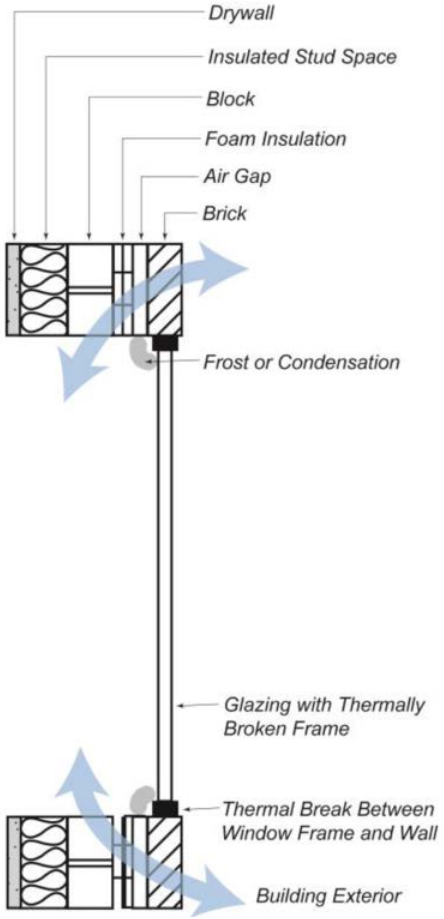


Solution

Thermal Bridges – Alignment of Fenestration



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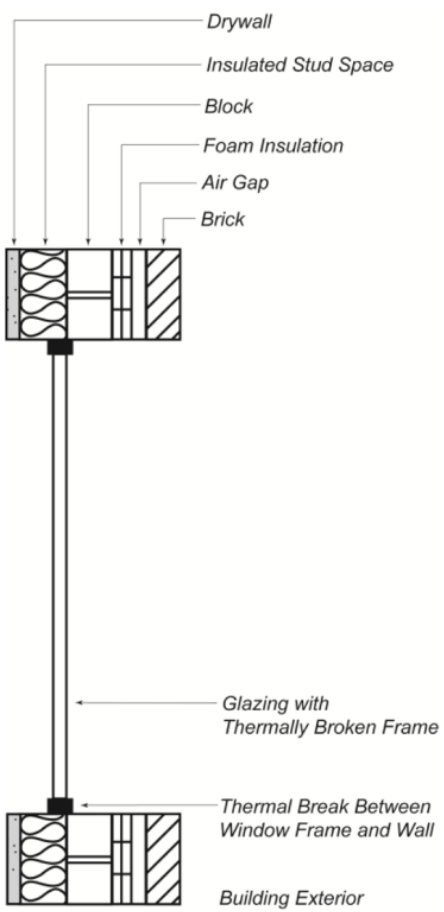
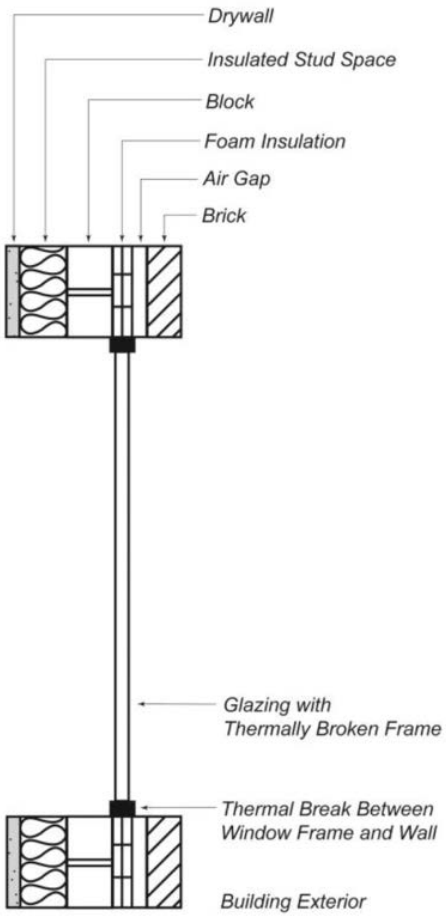


Solution 1



Solution 2

Appendix A Envelope Thermal Performance Factors
Table 1 Opaque Construction Options

Opaque Construction Options

Roof Assemblies	
Insulation Above Deck	
R	**U**
20 c.i.	0.048
25 c.i.	0.039
30 c.i.	0.032
35 c.i.	0.028
Metal Building	
19 +10 FC	0.041
19 + 11 Ls	0.037
25 + 11 Ls	0.031
30 + 11 Ls	0.029
25+11+11 Ls	0.026

Slabs	
Unheated	
R-in	**F**
15 - 24	0.52
20 - 24	0.51
20-48	0.434
Heated	
7.5 - 12.	1.02
10 - 24	0.90
15 - 24	0.86
20 - 24	0.843
20 - 48	0.688
25 - 48	0.671

Walls, Above Grade	
Mass Walls	
R	**U**
5.7 c.i.	0.151
7.6 c.i.	0.123
9.5 c.i.	0.104
11.4 c.i.	0.090
13.3 c.i.	0.080
15.2 c.i.	0.071
19.0 c.i.	0.048
Steel Framed	
13 c.i.	0.124
13 + 3.8 c.i.	0.084
13 + 5.0 c.i.	0.077
13 + 7.5 c.i.	0.064
13 + 10.0 c.i.	0.055
13 + 12.5 c.i.	0.049
13 + 18.8 c.i.	0.037
Metal Building	
0 + 9.8 c.i.	0.094
0 + 15.8 c.i.	0.060
0 + 19.0 c.i.	0.050
0 + 22.1 c.i.	0.044
0 + 25.0 c.i.	0.039
Walls, Below Grade	
R	**C**
7.5 c.i.	0.119
10 c.i.	0.092
15 c.i.	0.063

Floors	
Mass	
R	**U**
6.3 c.i.	0.107
10.0 c.i.	0.074
14.6 c.i.	0.056
16.7 c.i.	0.051
20.9 c.i.	0.042
23.0 c.i.	0.038
Steel Framed	
30	0.038
38	0.032

Daylighting and Electric Lighting

Michael Lane, LC
Puget Sound Energy

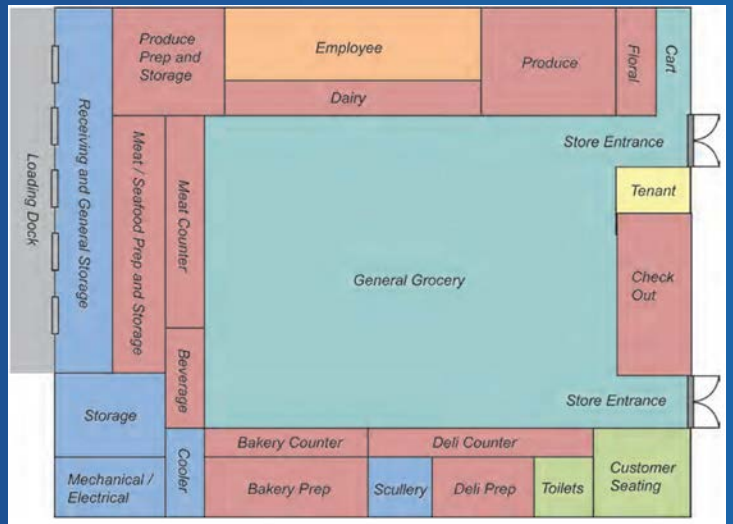


Figure 5-14 Grocery Space Planning Schematic

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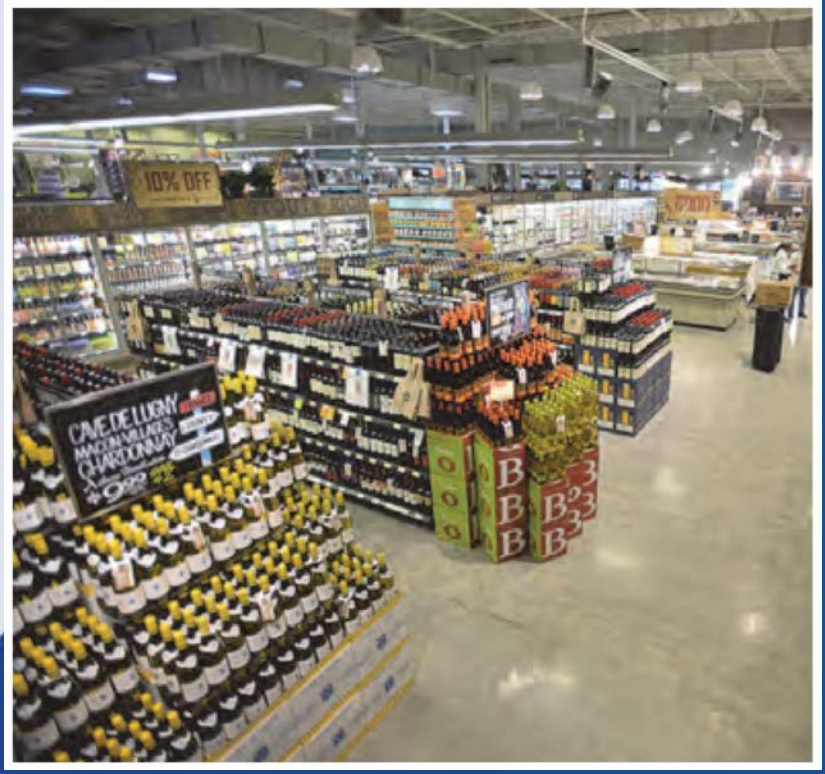
What is design?



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Goals for Grocery Lighting

- Lighting design for grocery sales spaces should support the goals of attracting customers, facilitating merchandise evaluation, and enabling completion of the sale.
- These goals can be obtained in consort with lower LPDs through the use of
  - high-efficacy light sources
  - lighting controls
  - good design practice.

Goals for Grocery Lighting

- **Ambient lighting.** Uniform general illuminance for merchandising areas as recommended in The Lighting Handbook (IES 2011) ranges from 15 to 50 fc depending on the store type and merchandising strategies.
  - Designing to the appropriate Illuminating Engineering Society of North America (IES) recommended ambient footcandle levels will establish the framework for an effective accent lighting strategy that achieves accent lighting goals without sacrificing energy efficiency.

Goals for Grocery Lighting

- **Perimeter lighting.** Illuminance ratios of no more than 2:1 of ambient light levels are recommended for the creation of effective perimeter wall lighting.
  - Effective perimeter lighting includes adequate illumination levels for merchandise evaluation as well as for contributing to the perceived brightness within the space.
  - Using T8, T5, or light-emitting diode (LED) luminaries is an energy-effective option for creating perimeter lighting.

Goals for Grocery Lighting

- Accent and/or task lighting. Accent and task lighting provide additional illumination required to enhance merchandise color, texture, and detail. Task lighting levels are typically 1 1/2 to 2 times that of ambient lighting.
  - Some tasks or product evaluation may require higher ratios and to create visual contrast and interest, accent lighting ratios of 5:1 (accent to general ambient and/or perimeter) should be designed as recommended in The Lighting Handbook.
  - Effective accent lighting is best accomplished with point source directional luminaries such as ceramic metal halide (CMH) and LED, which also represent the most energy-efficient accent option.

EL10 Color Rendering Index (Climate Zones: all)

- The color rendering index (CRI) is a scale measurement identifying a lamp's ability, generally, to adequately reveal color characteristics. The scale maximizes at 100, with 100 indicating the best color-rendering capability.
  - It is recommended that lamps specified for the ambient, tasks, and accent lighting of merchandise and service areas within customer spaces have a CRI of 80 or greater to allow the consumer to effectively examine the color component of a product.

EL11 Color Temperature (Climate Zones: all)

- Color temperature is a scale identifying light source relative warmth or coolness—the higher the color temperature, the bluer the source.
  - There are preliminary studies showing that higher-color-temperature light, in the 5000 K range instead of the 3500 K range, may provide better visual acuity; however, 5000 K lamps may produce an artificially cool-looking building at night.
  - The higher 5000 K color temperature will also match the daylight from windows and skylights more closely than the lower 3500 K color-temperature sources.
  - The decision as to which lamp color or multiple of lamp colors is used will be determined by merchandise objectives, brand identity, and operational considerations.

EL20 General Lighting in Grocery Sales Areas (Climate Zones: all)

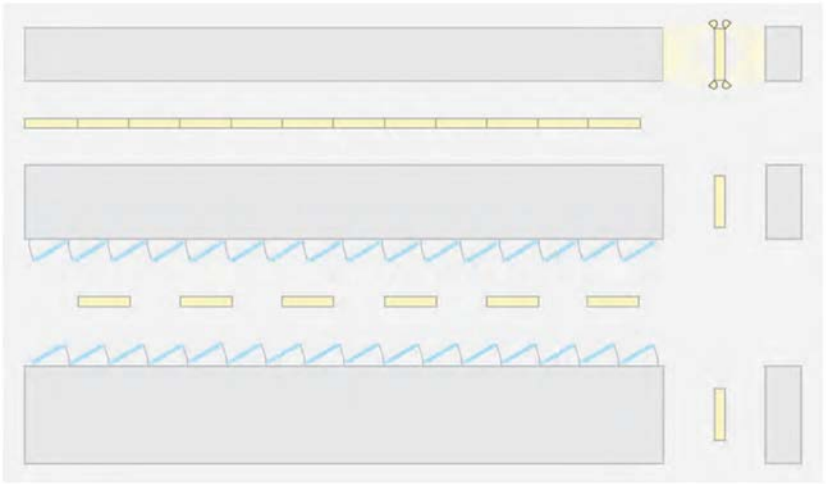


Figure 5-17 (EL20) Layout for Lighting in Merchandise Sales Area

- General lighting at 1.15 W/ft^2 provides the base level of lighting for the merchandise. Spill light from the merchandise general lighting will provide adequate lighting for the circulation paths

Controls

- Sales Floor = Time switch -- auto to 25% during closed hours, auto to 2% or less when unoccupied

EL21 Accent Lighting in Merchandise Sales Areas (Climate Zones: all)

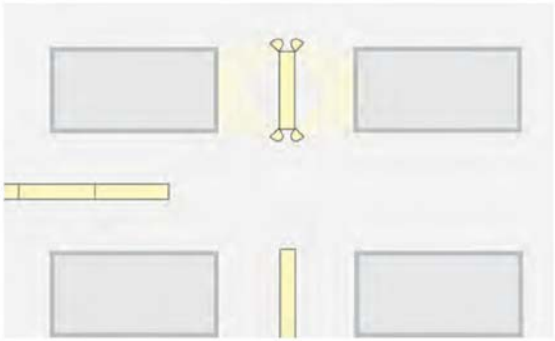


Figure 5-19 (EL23) Accent Lighting in Merchandise Sales Area

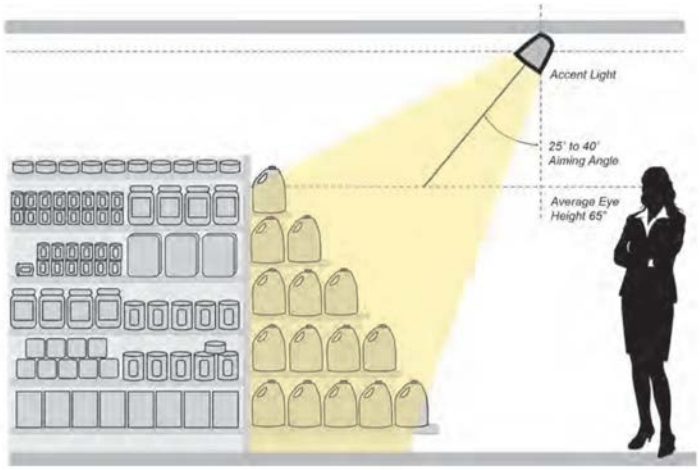


Figure 5-15 (EL4 and EL5) Accent Lighting Aimed at 40 Degrees

- Use LED task and accent lighting to highlight key merchandise locations or vignettes to “feature display” light levels (three to ten times the general merchandise lighting level in the area of the display). The use of accent lighting to highlight all merchandise does not create the proper contrast ratios and should be avoided.

Controls

- Accent lighting = Auto ON only during store open hours

Daylighting

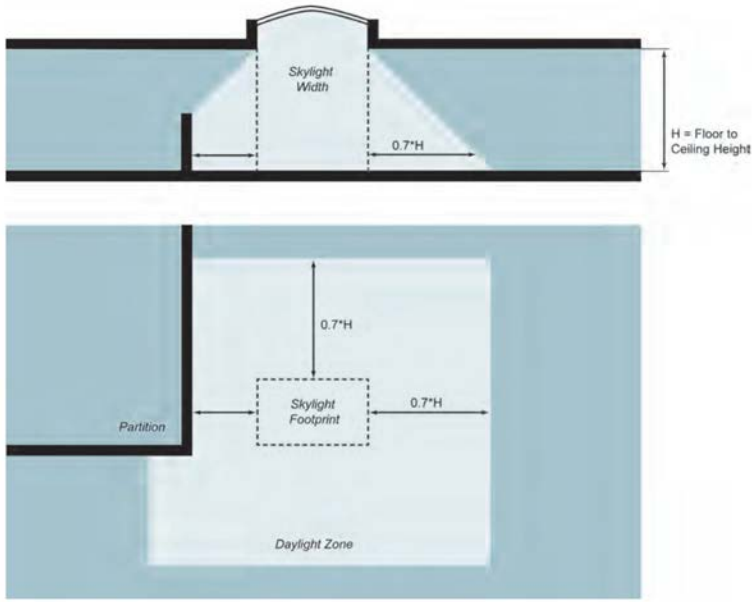


Figure 5-11 (DL6) Daylight Zone under Skylight

- Toplighting – skylights or rooftop monitors are required per ASHRAE/IES Standard 90.1 (ASHRAE 2013) in climate zones 1 through 5 in spaces greater than 2500 ft^2 directly under a roof with ceiling heights greater than 15 ft
- Follow the prescriptive requirements of Standard 90.1 and install skylights that daylight at least 50% of the sales floor area

Controls

- General lighting auto controlled in response to daylight

Climate Zone table - Daylighting

	Item	Component	Recommendation	How-to Tips	✓
	Daylighting	Skylights or rooftop monitors	Required per Standard 90.1 when sales floor ceiling height > 15 ft and area is ≥ 2500 ft^2	DL1–10	
		Daylight area	≥ 50% of the sales floor	DL1–10	
		Skylight to daylight area	Minimum = 3%, maximum = 5%	DL3	
		VT	Skylight VT ≥ 0.40	DL3	
		Skylight SHGC	0.35	EN25–27	
		Skylight thermal transmittance	U-0.65	DL4	
		Effective aperture	Skylight effective aperture ≥ 1%	DL8	
		Glazing material/diffuser	Measured haze value > 90% when tested according to ASTM D1003 (ASTM 2013)	DL3	
		Controls	General lighting auto control in response to daylight	DL6–7, 9–10	

- Skylights are not required in Climate Zones 6 through 8

Skylight Option

Tubular Daylighting Devices

Tubular daylighting devices (TDDs) are one daylighting option now being used with greater frequency. The devices harvest daylighting through roof-mounted domes connected via a tubing system to a diffuser that looks very similar to a ceiling light fixture. The result is an effective daylighting source with less heat transfer than traditional skylights or roof monitors that can provide significant annual energy and operating cost savings.

Roof-Mounted Domes for Tubular Daylighting Devices

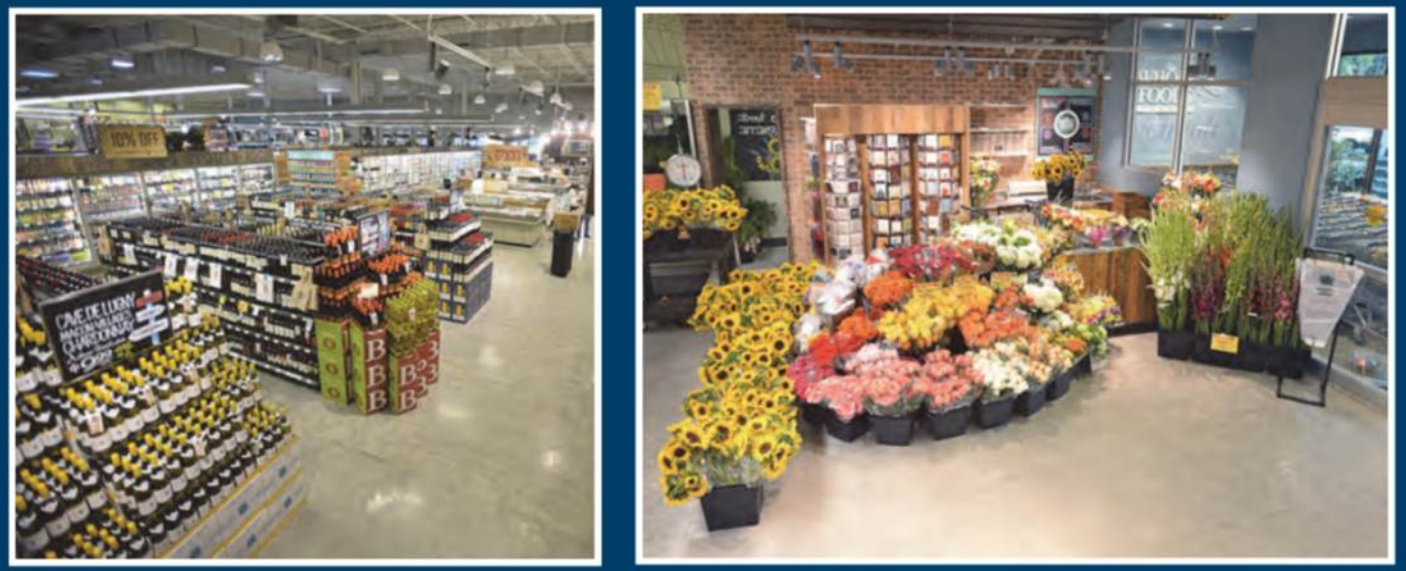
Photographs reproduced with permission of Giant Eagle, Inc. (left) and Solatube International (right)

Climate Zone Table – Interior Lighting

	Item	Component	Recommendation	How-to Tips	✓
Daylighting / Lighting	Interior Lighting	Ambient and accent lighting	Sales floor LPD = 1.15 W/ft^2	EL1, 3–7, 9–11, 17, 25, 30	
			Stock room LPD = 0.6 W/ft^2	EL1, 4, 9–11, 17–19, 29–30	
			Average of all other LPDs = 0.8 W/ft^2	EL1–2, 4, 8–11, 17–19, 25–27, 29–30	
		Light source lamp efficacy (mean lumens per watt)	LED—general = 80, accent = 75, case = 50 LED—exterior = 75 T8 and T5—greater than 2 ft = 92, 2 ft and less = 85	EL12, 14	
		T8 ballasts	Nondimming = NEMA Premium instant start Dimming = NEMA Premium program start	EL12	
		All T5/T5HO ballasts	Electronic program start	EL12	
		All CFL and HID ballasts	Electronic	EL12	
		Lighting controls	Sales floor = time switch—auto to 25% during closed hours, auto to 2% or less when unoccupied	EL16	
			Additional specialty lighting = auto ON only during store open hours	EL16	
			Stock room, restrooms = auto ON/OFF occupancy sensors	EL15	
			All other = manual ON, auto OFF occupancy sensors	EL15	
			After hours = maximum 2% of total building LPD	EL16	

Layering of Light

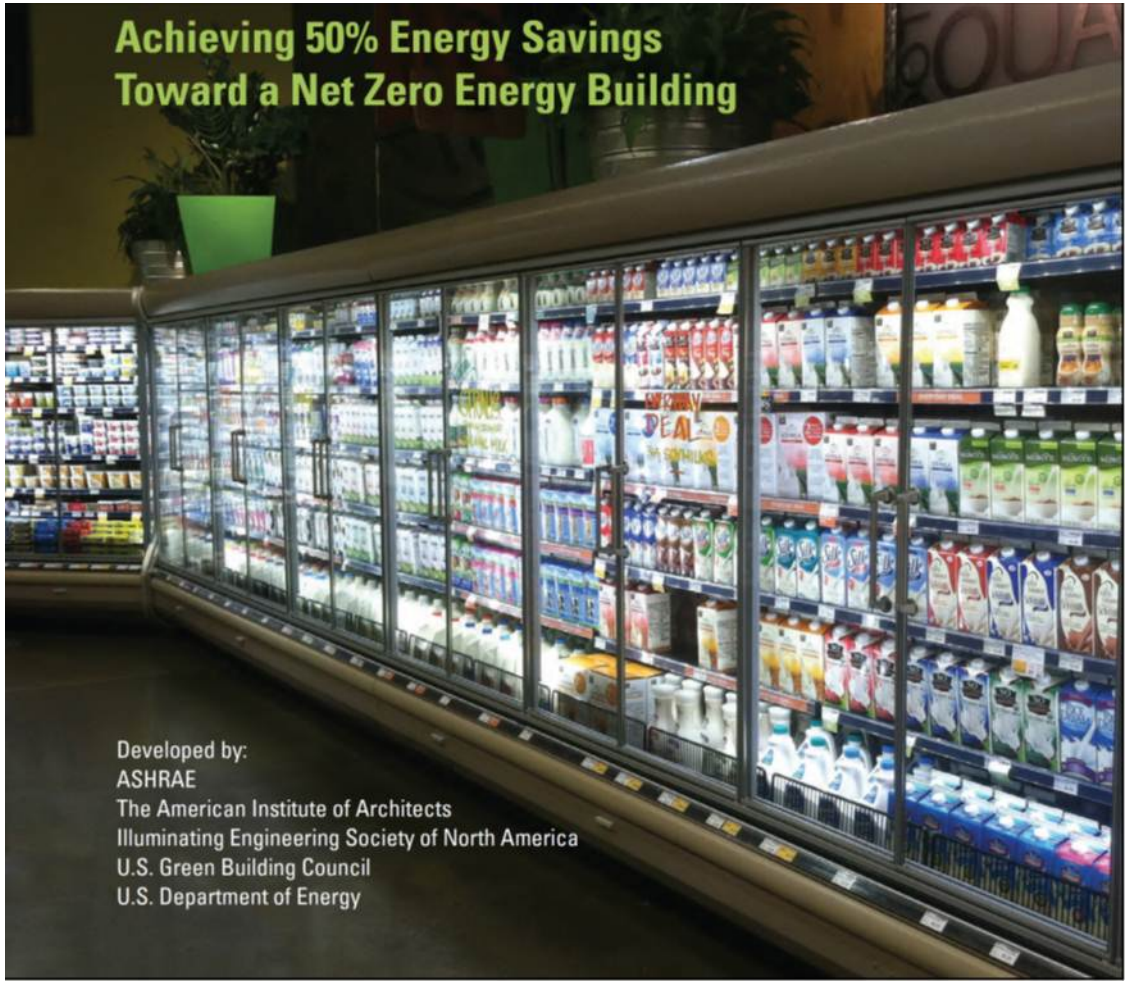
Using high-efficacy luminaires coupled with a layered lighting strategy produces dynamic lighting with accents and feature display illumination while meeting or exceeding code compliance and energy targets. In some applications, total LPD may actually be lower than that of the LPD used to produce bright, uniform lighting.



Accent and Display Lighting Strategies

Photographs reproduced with permission of Whole Foods Market

Layering of Light



Climate Zone Table – Exterior Lighting

	Item	Component	Recommendation	How-to Tips	✓
	Exterior Lighting	Façade and landscape lighting	LPD = 0.075 W/ft² in LZ3 and LZ4, 0.05 W/ft² in LZ2 Controls = auto OFF at business closing	EL33–35	
		Parking lots and drives	LPD = 0.08 W/ft² in LZ3 and LZ4, 0.05 W/ft² in LZ2 Controls = occupancy sensor to at most 50% power	EL31, 34–35	
		Walkways, plazas, and special feature areas	LPD = 0.16 W/ft² in LZ3 and LZ4, 0.14 W/ft² in LZ2 Controls = occupancy sensor to at most 50% power	EL32, 34–35	
		All other exterior lighting	No recommendation*	EL34–35	

TABLE 9.4.2-2 Individual Lighting Power Allowances for Building Exteriors

	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
.....					
Uncovered Parking Areas					
Parking areas and drives	No allowance	0.04 W/ft²	~~0.06~~ 0.05 W/ft²	~~0.10~~ 0.06 W/ft²	~~0.13~~ 0.08 W/ft²
.....					

Daylighting and Electric Lighting

Michael Lane, LC
Puget Sound Energy

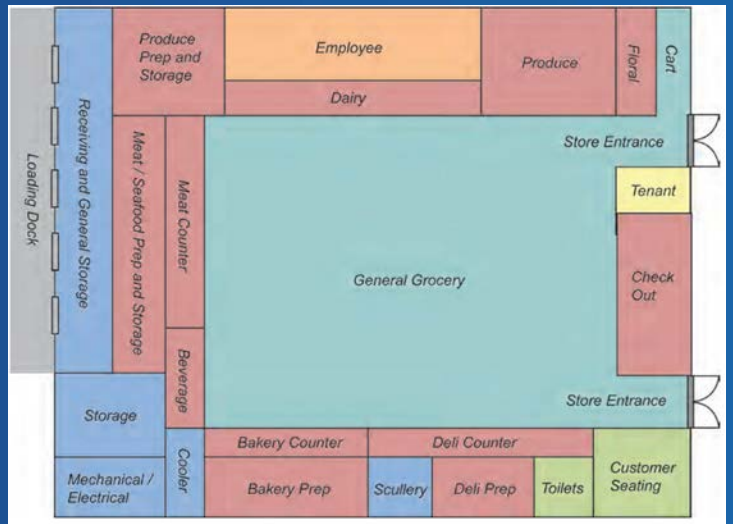


Figure 5-14 Grocery Space Planning Schematic

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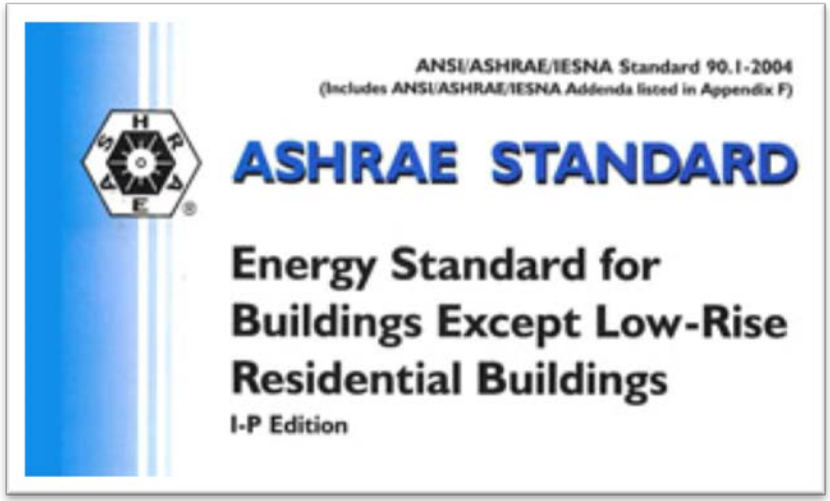
Refrigeration and HVAC

Caleb Nelson, P.E.

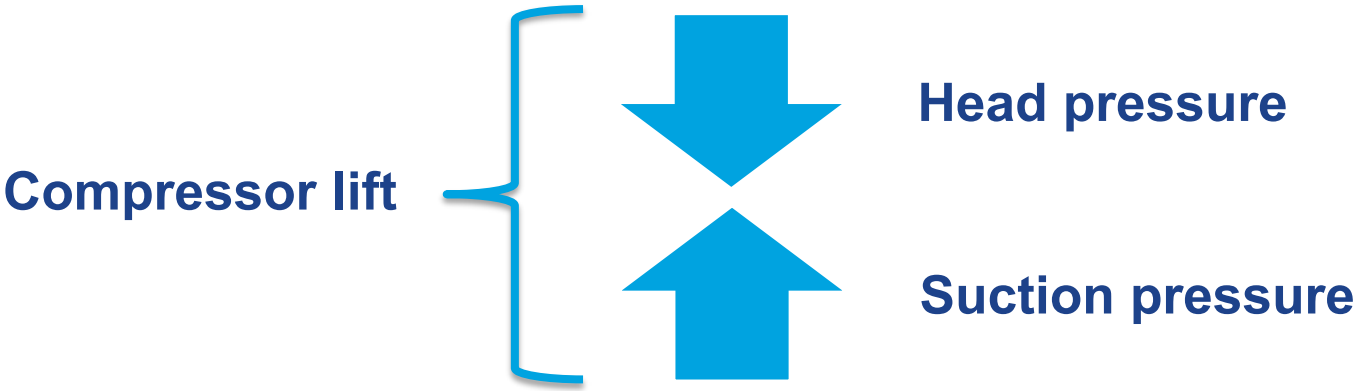
Refrigeration

- New discipline for AEDG
- Baseline
  - ASHRAE 90.1 – 2004



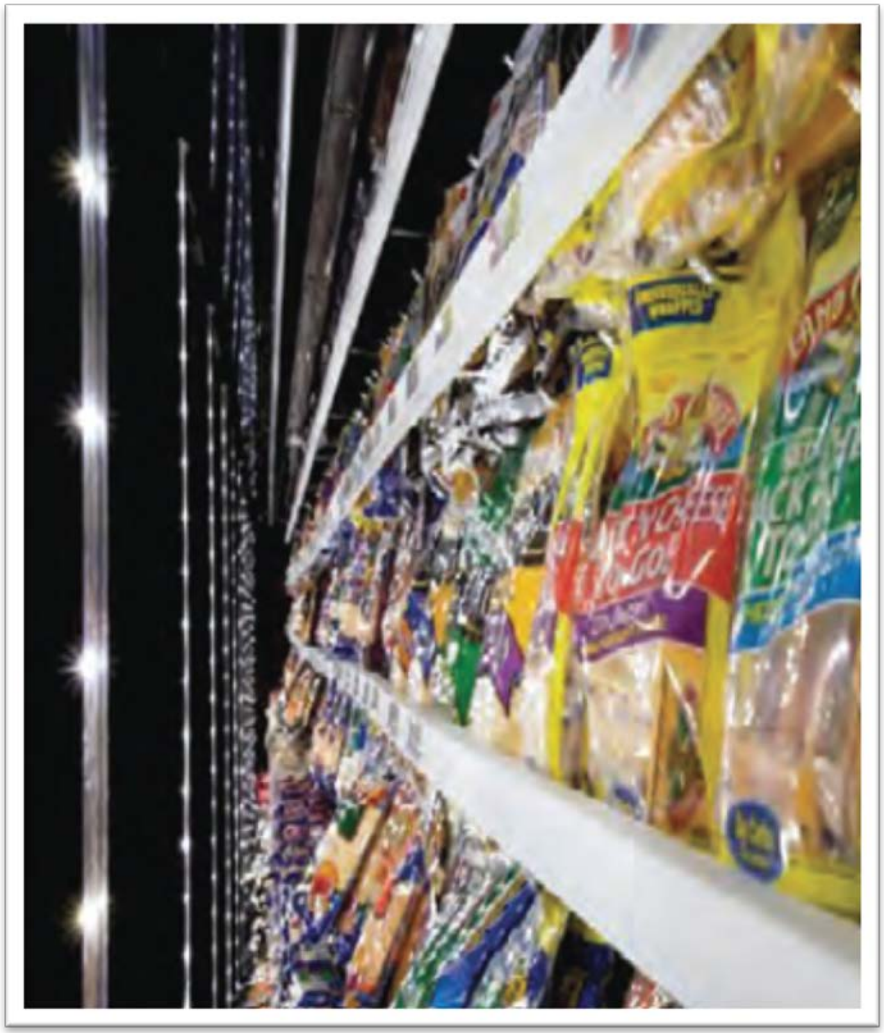
Refrigeration – Energy Reduction

- Specifying efficiency is not enough
- Simplifying refrigeration system efficiency:
  - Reduce **LOAD**
  - Reduce **LIFT**



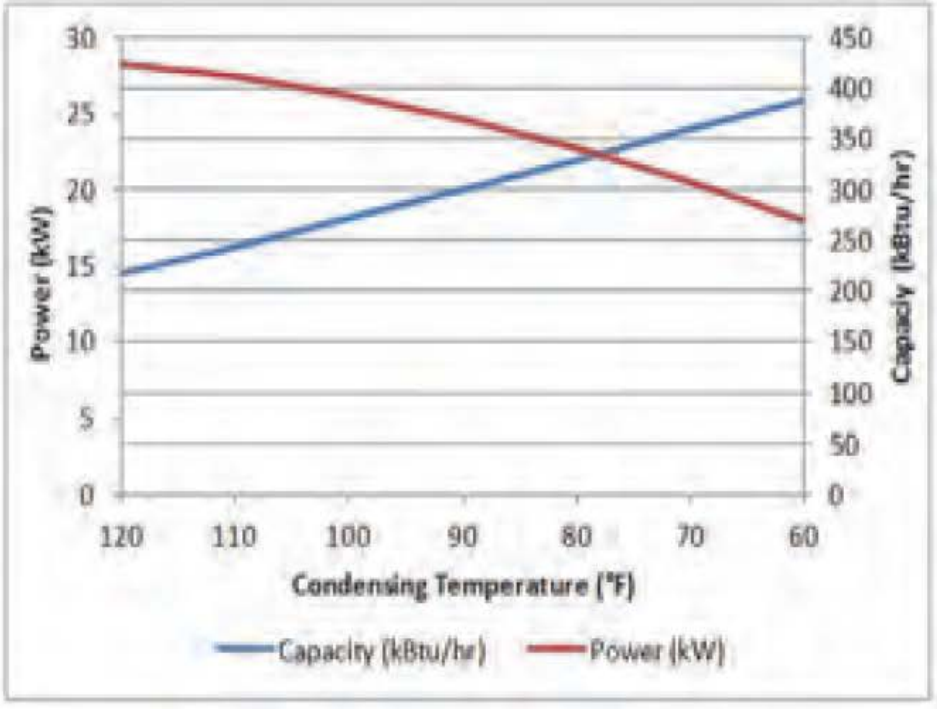
Refrigeration – Energy Reduction

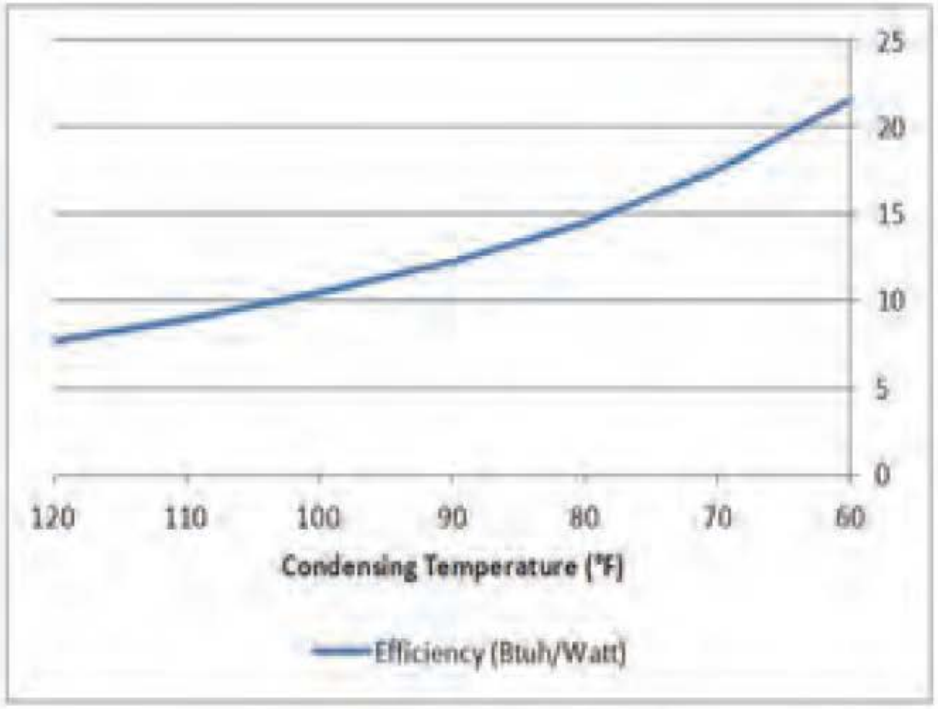
- Reducing Load
  - Reduces compressor size
  - Reduces condenser size
- Examples
  - Insulation
  - Case LEDs
  - Doors on Cases



Refrigeration – Energy Reduction

- Reducing Lift
  - Takes advantage of:
    - Reduced ambient temperatures
    - Part load operation
  - Affects system capacity and COP
- Examples
  - Doors on Cases
  - Electronic Valves
  - Suction Grouping
  - Floating Controls

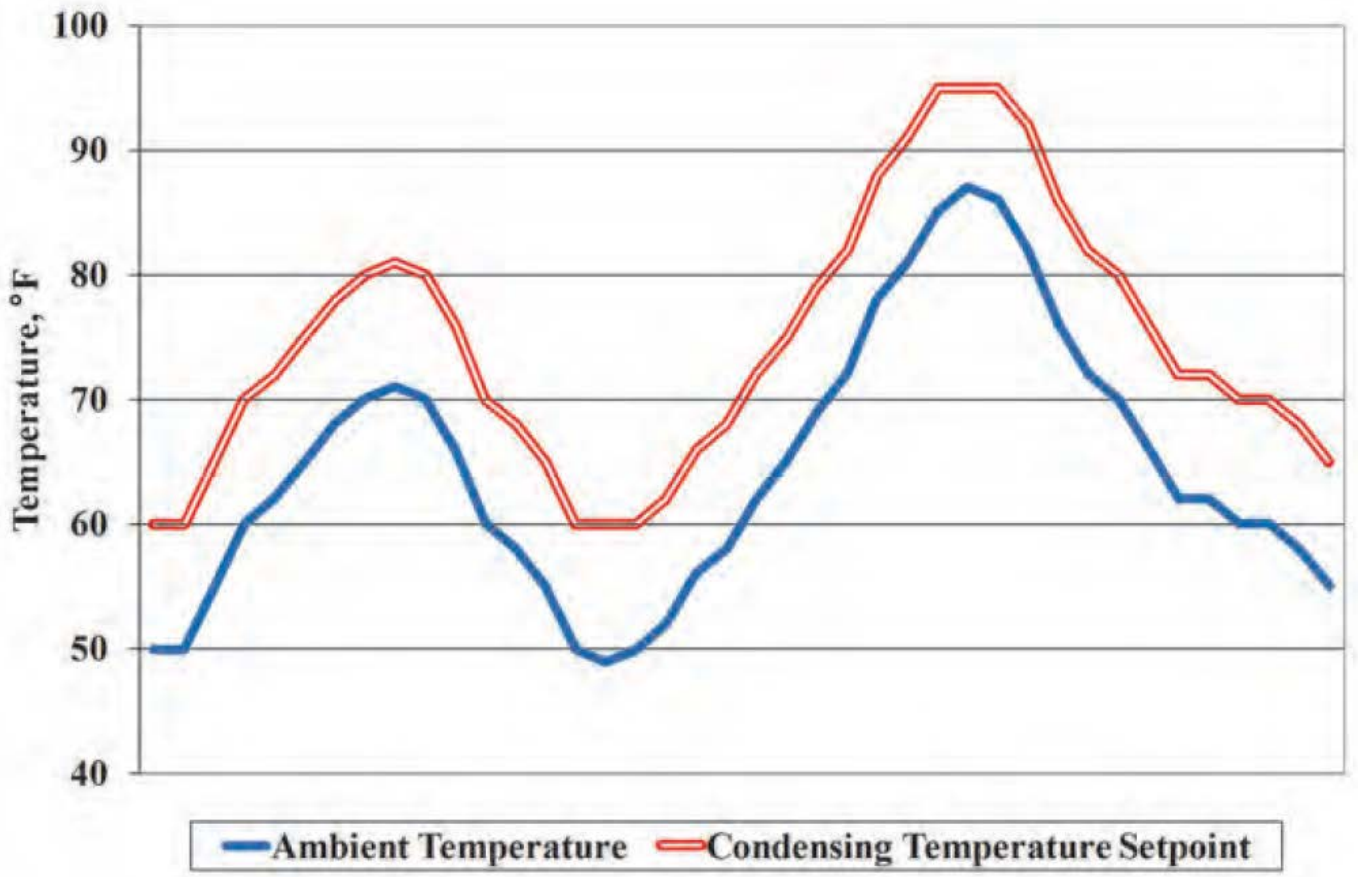




Refrigeration – Energy Reduction

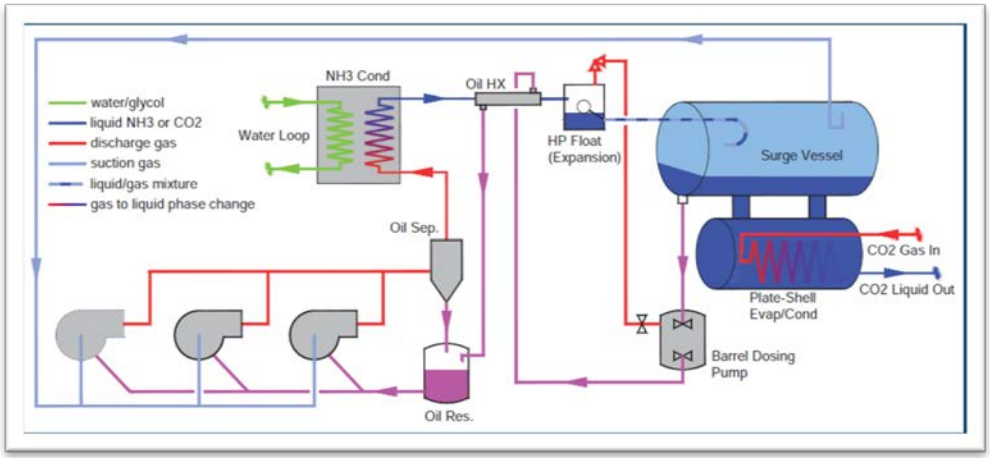
Reducing Lift

- Hinges on proper design and control



Refrigerant Impact

- Dealing with Refrigerant GWP
  - Must consider Energy impact
- System Architectures
- Refrigerant Glide



Refrigeration & HVAC Interactions

- Thermal Comfort
  - Increased heating demand
  - Reduced cooling demand
  - Cold Aisle
- Heat Reclaim
  - Water
  - Air (heat and reheat)

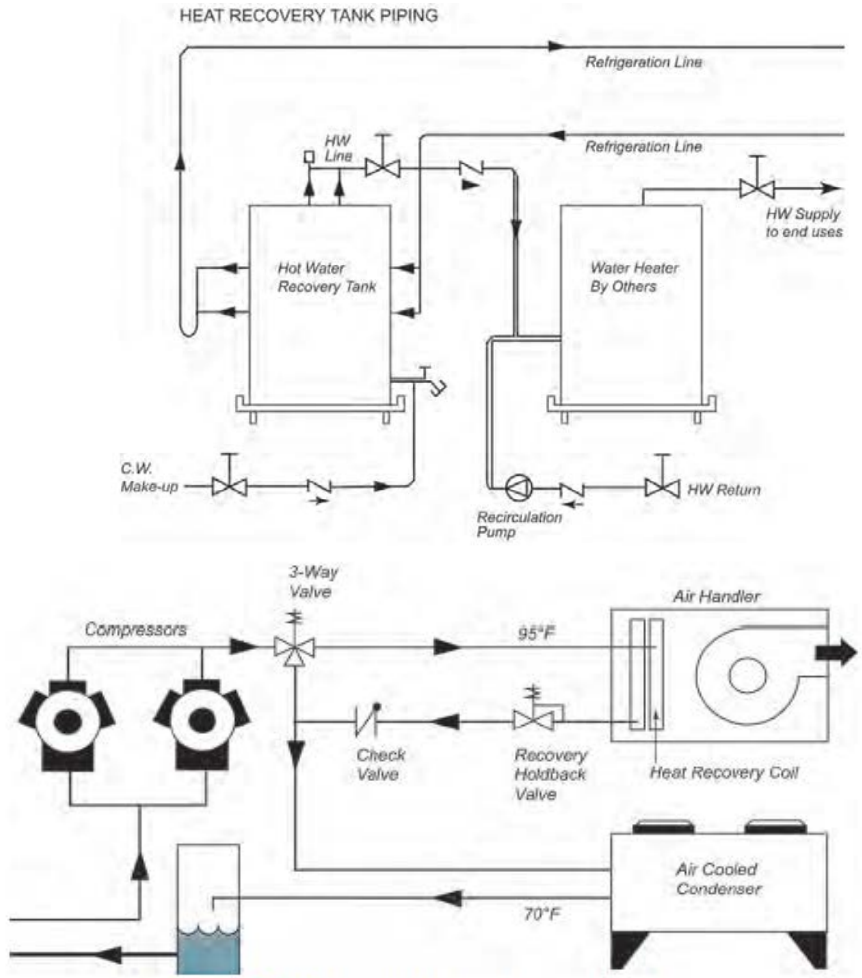
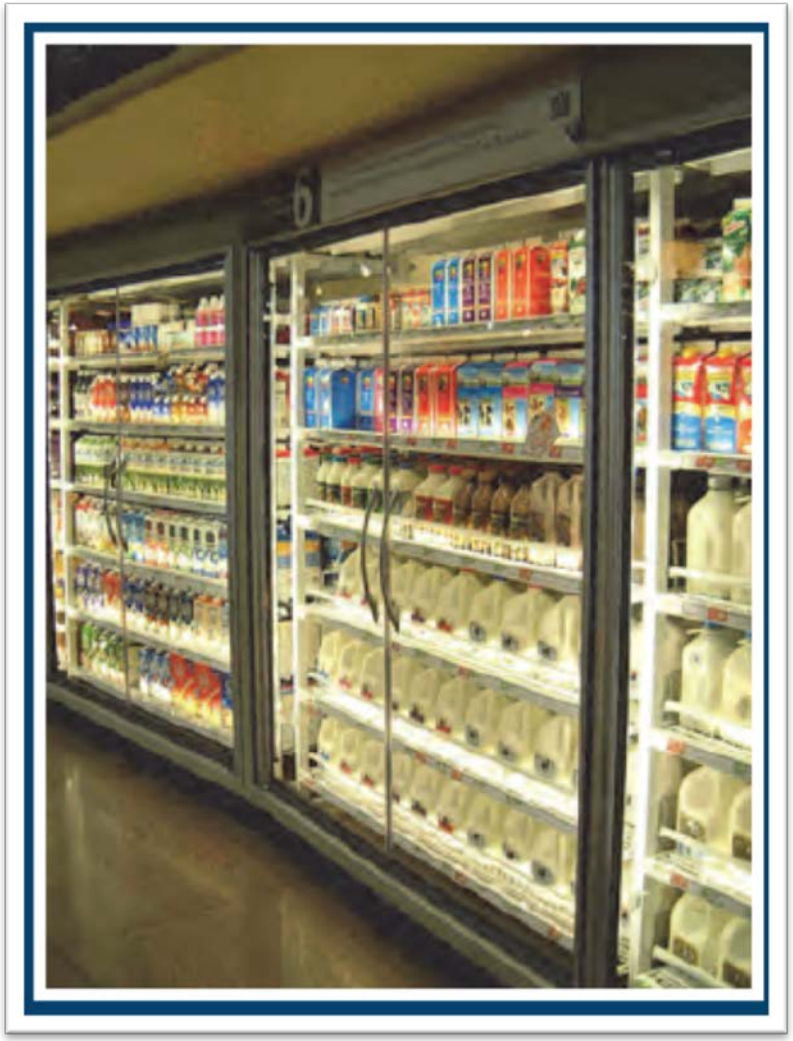


Figure 5-31 (RF29) Conventional Series-Connected Heat Recovery

Refrigeration & HVAC Interactions

- Dehumidification
  - Required store condition: 75°F/55% R.H.
  - Refrigeration COP vs. A/C COP
  - Anti-sweat heater control



HVAC

- Kitchen Equipment
  - DCKV (Demand Controlled Kitchen Ventilation)

Case Study

Whole Foods Market—A Case Study

Refrigeration

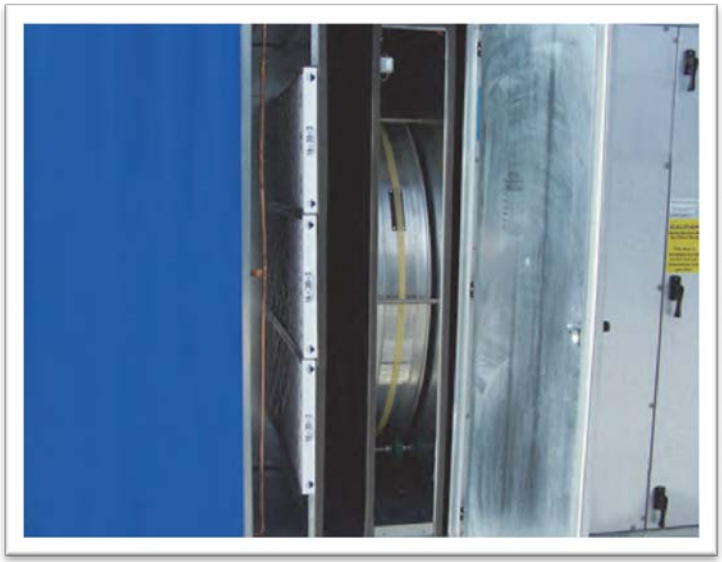
- Case doors
- A.S. control
- LED
- EC motors

HVAC

- Desiccant wheel
- Heat Reclaim
- Reduced airflow / Fan savings

Kitchen

- Hood side panels
- DCKV responds to heat/smoke



Case Study

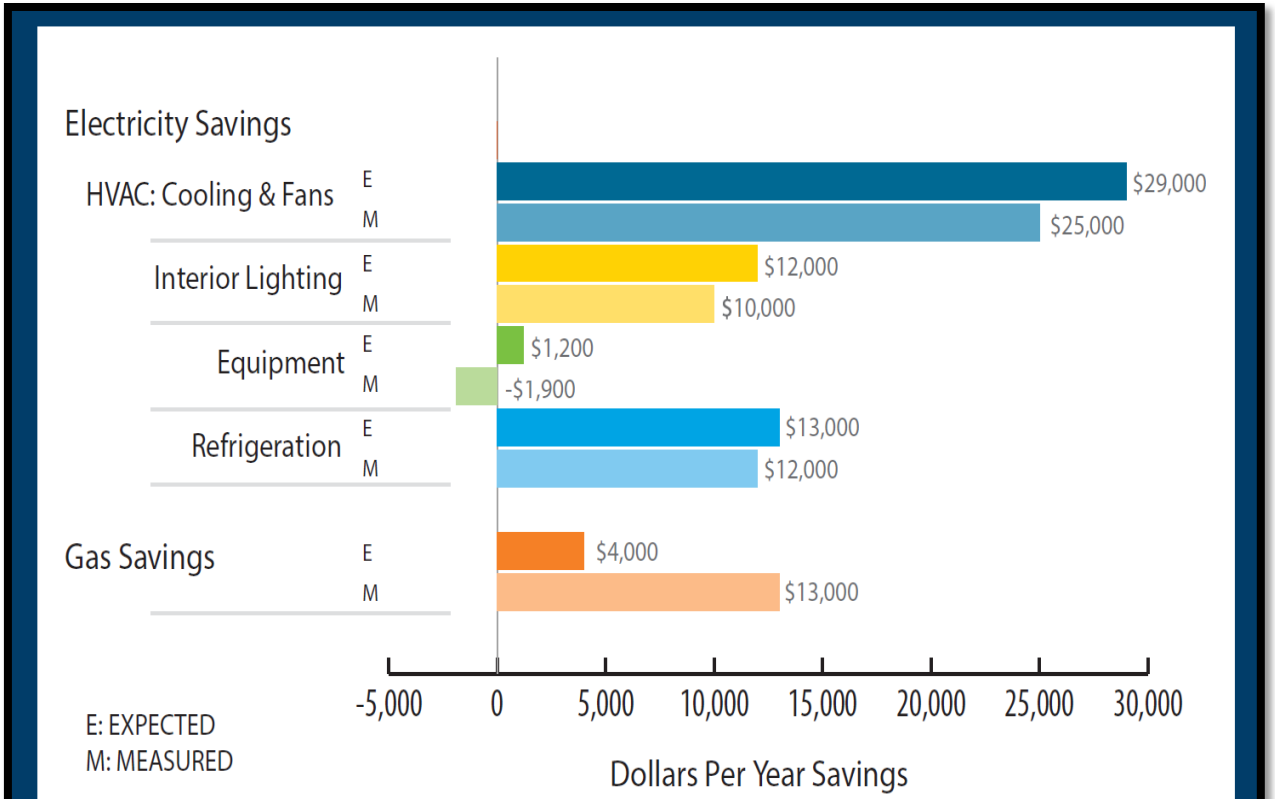
Whole Foods Market—A Case Study

Lighting

- 1 W/sf lighting
- Skylights
- LED
- Controls

Resulting EUI:

290 kBtu/ft2



Expected and Measured Energy Cost Reductions

Source: EERE (2013)

Questions?

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