Designing For Energy Efficiency

“Great Supermarket Design”

- Great supermarket design is different from what most of us would commonly consider great design for other kinds of facilities.
- It is more about the facility functionality and customer shopping experience than facility architecture and exterior appearance.
- More about substance than ego, or should be.

Great Design Really Counts in the Supermarket Business!

Great Institutional Building Designs

Bilbao Art Museum - Frank Gehry

Guggenheim Art Museum - Frank Lloyd Wright

Cathedral of Christ the Light - SOM

Great Design Really Counts in the Supermarket Business!

Great Architecture But Great Supermarket Designs??

Great Design Really Counts in the Supermarket Business!

You Can Put Lipstick On A Box, But It Is Still A Box

The Lipstick Out Front…

The Box Behind…

Great Design Really Counts in the Supermarket Business!

“Great Supermarket Design”

For Great Supermarket Design, It’s About What’s Inside The Box, and About Making All Design Elements Work For The Customer, Employees, and Shareholders.

“Great Supermarket Design”

Shopping/selling areas…

Great Design Really Counts in the Supermarket Business!

“Great Supermarket Design”

and behind the scenes…

Great Design Really Counts in the Supermarket Business!

“Great Supermarket Design”

1. Is exciting and inviting (brighter, lighter, more dramatic, greener) for customers and store personnel
2. Is comfortable and convenient for customers and store personnel
3. Displays perishable merchandise effectively while carefully preserving its quality and safety
4. Is durable and cost less to maintain/repair
5. Has a reduced environmental footprint
6. Has a reduced construction cost or time or both, compared to traditional designs

AND USES LESS ENERGY!

“Great Supermarket Design”

Makes it easy and pleasant for:

- customers to shop
- for employees to do their jobs very, very well

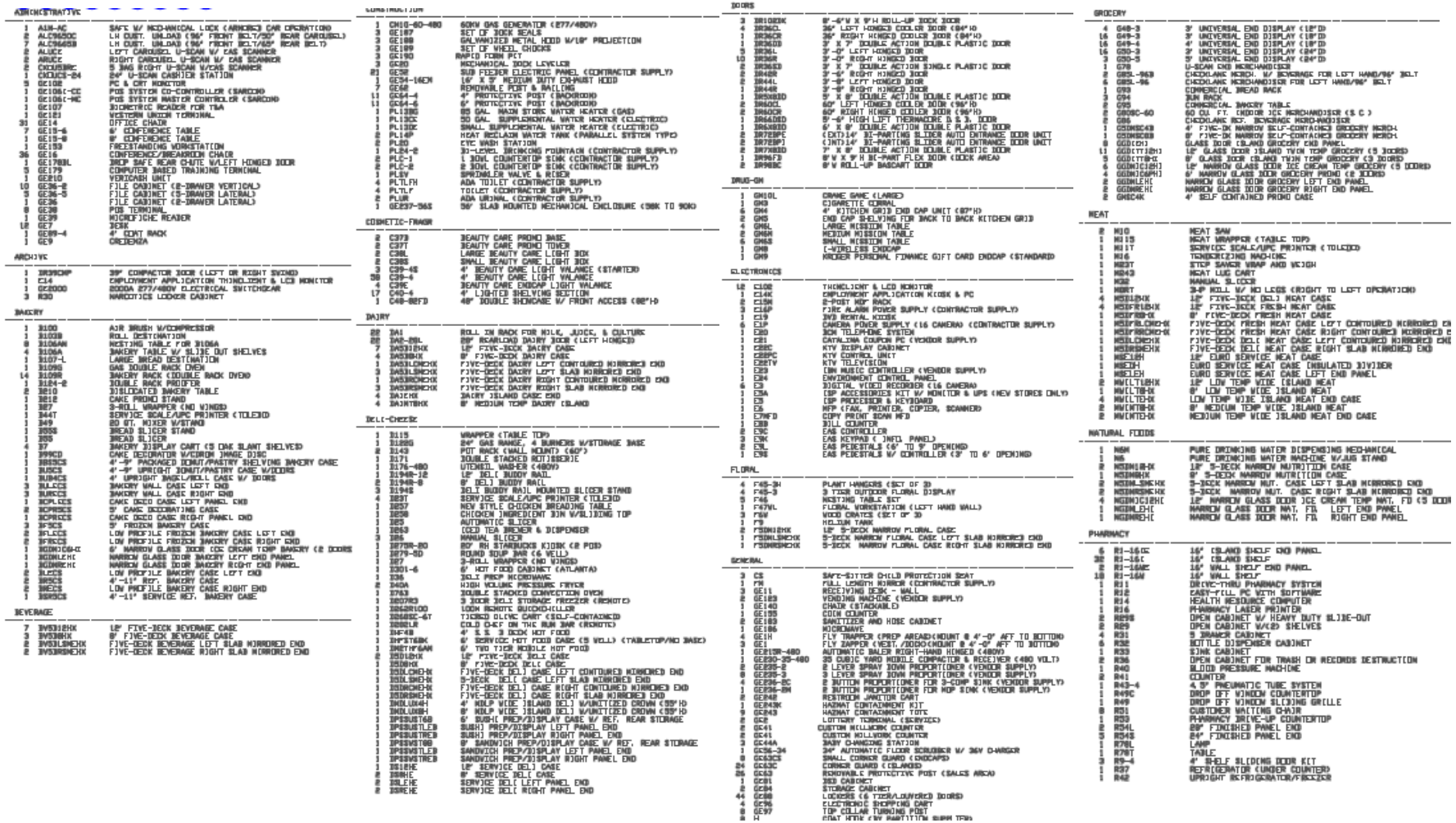
AND USES LESS ENERGY!

Great Supermarket Design - Challenges

1. Large number of departments with very different physical layout, appearance, equipment and MEPR support requirements:
   - Bakery Prep and Sales - from scratch to bakeoff only
   - Deli Prep and Sales
   - Meat Prep and Sales
   - Produce Prep and Sales
   - Front End and Customer Service
   - Taqueria and Tortilliaria
   - Fuel Stations, Bottle Return Facilities, Other

Great Supermarket Design - Challenges

- A daunting number of equipment items and types



Great Supermarket Design - Challenges

2. Substantial refrigerated storage and display requirements
   - Increasing number of perishable offerings
   - Increasingly sophisticated perishable offering displays and refrigerated display fixtures (damned merchandisers!)
   - Impose difficult perishable product quality, customer comfort, and energy efficiency and maintenance expense challenges
3. Receive and stock large amount of product cube/tonnage and SKUs every day
   - Floor surfaces take a beating
   - Materials handling equipment needs wide access lanes

Great Supermarket Design - Challenges

4. Large number of shoppers with very significant peak traffic periods and high level of convenience required at all times

5. Extremely competitive business environment – store has to look very good to be competitive, yet be buildable at an acceptably low cost, and operate with low energy and maintenance expense levels

Great Supermarket Design

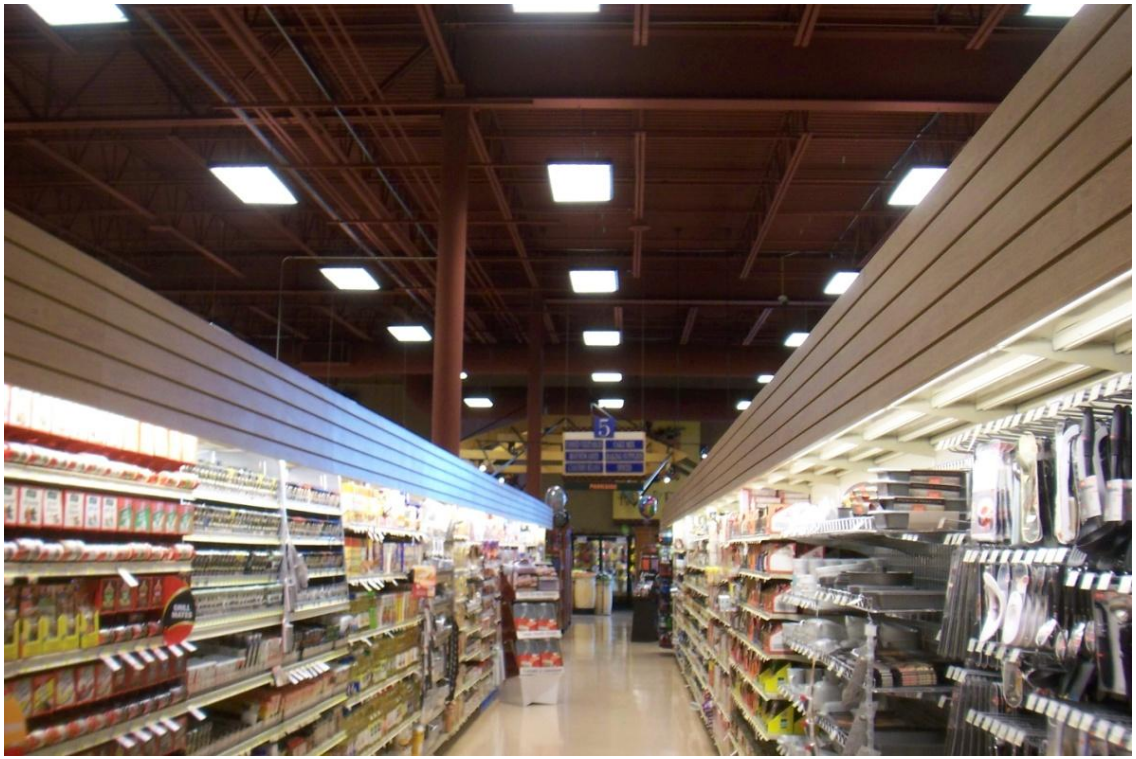
Energy efficient supermarkets with ‘Great Design’ meet these challenges by incorporating great design elements. Some examples are:

- Best practice grocery sales area lighting
- Electronic expansion valves
- Daylighting in sales and support areas
- Medium temperature glass door reachins
- Best practice product highlighting
- LED interior signage
- Optimized building size and height
- Central plant HVAC
- Hydronic refrigeration heat reclaim

Great Design Really Counts in the Supermarket Business!

Grocery Sales Area Lighting

Not-So-Great design….



Excess Lighting!

- Light level readings at the center of the aisle were in excess of 200 fc and lighting power levels were in excess of 3 watts/ft2
- Grocery sales area lighting with 2 lamp fluorescent valance lighting and 6 lamp fluorescent fixtures above.
- More lighting is needed to compensate for dark ceiling and bulky, overhanging valances.

Great Design Really Counts in the Supermarket Business!

Grocery Sales Area Lighting

Great Design!

Just enough of just the right type of lighting

Best light source and fixture type – T8 and T5 fluorescent strip lighting are still the most effective lighting system for general grocery sales area. Can achieve excellent illumination at 1.5 watts/ft2 or lower lighting power levels.

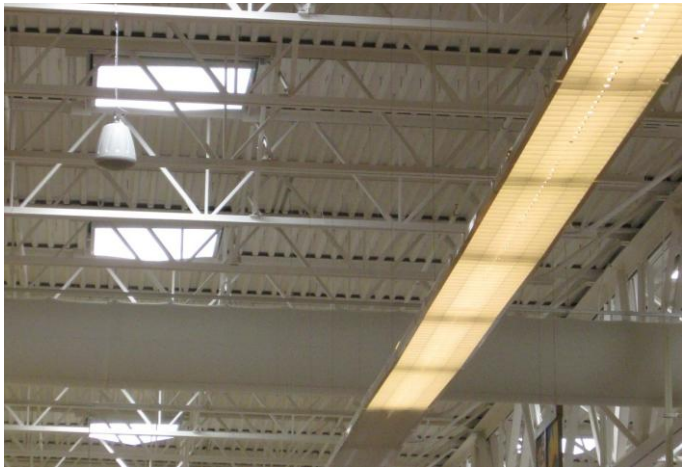
Great Design Really Counts in the Supermarket Business!

Grocery Sales Area Lighting

Great Design!

Effective Lighting Control

2 lamp row fixtures allow 2 levels of FMS lighting control, 3 lamp row allow three levels, useful when significant daylighting available. Dimming T5 fixtures now an attractive control option. **Lighting control is the most important lighting energy efficiency factor!!!**



Great Design Really Counts in the Supermarket Business!

Grocery Sales Area Lighting

Great grocery sales area lighting design starts with:

- T8 or T5 strip lighting,
- light colored ceilings,
- limited use of gondola valances

Great grocery sales area lighting design supports:

- Value and low price messages
- Better operating margins to pass on lower prices

Great grocery sales area lighting is simple and well controlled.

T8/T5 Fluorescent Strip Lighting W. FMS Control	
Exciting and inviting	
Comfortable and convenient	√
Effective merchandising display	√
Durable and low maintenance	√
Reduced environmental footprint -	
Reduced construction cost or time	√

Plus it saves energy!

Product Highlighting

Not-So-Great Design

Lighting design is multi-layered and redundant

- too much ambient lighting from HID fixtures washing out targeted lighting from spot lights.
- >2+watts/ft2

Great Design Really Counts in the Supermarket Business!

Product Highlighting

Not-So-Great Design

Mixture of spot, ambient lighting and internal case lighting.

- Spot lighting is not effective, watts/ft2 are high, energy being wasted.
- Environment confusing and lacks punch.

Ineffective Case Lighting

Great Design Really Counts in the Supermarket Business!

Product Highlighting

Better Design

Mixture of LED spot and fluorescent ambient lighting.

- Simple and effective lighting – just enough ambient delivered by fluorescent fixtures, but not so much that spot light fixtures don’t highlight product
- < 2 watts/ft2

Great Design Really Counts in the Supermarket Business!

Product Highlighting

Better Design

Ceramic metal halide spots only

- The sole lighting source in these produce areas is from ceramic metal halide spot lights
- 1 to 1.5 watts/ft2

Great Design Really Counts in the Supermarket Business!

Product Highlighting

Great Design!

LED spot lighting only

- Lowest lighting power levels at <1.0 watts/ft2

Great Design Really Counts in the Supermarket Business!

Product Highlighting

Great Design!

Fixtures/displays with internal case lighting

- no external spot lighting aimed at fixtures
- Let the internal fixture lights (LED) highlight the product!

Open fixtures/displays

- For fixtures without internal lighting, let LED spot lights illuminated the product unassisted by other sources.

Great Design Really Counts in the Supermarket Business!

Product Highlighting Analysis

Description	Installed Cost	watts/ ft2	KWh	KW/yr	Rate	Operating Cost	Maintenance Cost	Annual Cost
Combined ambient fluorescent or HID w/ HID spots	$10,500	2.2	13.2KWh	86,500	0.1	$8,650	$1,600	$10,250
Track system w/fluorescent and HID spots	$7,500	1.9	11.4KWh	74,700	0.1	$7,470	$1,500	$8,970
HID (ceramic metal halide) spots only	$5,000	1.3	7.8 KWh	51,100	0.1	$5,110	$1,750	$6,860
LED spots only	$6,000	0.85	5.1 KWh	33,400	0.1	$3,340	$500	$3,840

Notes: Based on 6,000 ft2 perishables department

Operating hours - 18 hrs/7 days/52 weeks = 6,552 hrs/yr.

Product Highlighting

Great Design - LED spot lighting as sole lighting source:

- Improves illumination of product
- At 50,000 hrs of life require only one change per 8 – 10 years of operation
- Is lowest in UV output
- Dimmable for night lighting mode

Perishables Department Lighting	
Exciting and inviting	√
Comfortable and convenient	
Effective perishable display	√
Durable and low maintenance	√
Reduced environmental footprint -	√
Reduced construction cost or time	

Plus saves energy, a lot of it!

Interior Signage Lighting

Not-so-great designs

Wall signage lit by multiple sources. Ambient, wall wash, and spot lighting all in play here.

Interior Signage Lighting

Great designs!

LED back lighting. Modest but effective signage illumination and resulting signage punch.

Theatrical style LED spot lighting on signs. Low energy and effective.

Great Design Really Counts in the Supermarket Business!

Daylighting – Walls & Storefronts

This great design practice is seen in many older store facades …

Large storefront windows allow natural lighting and attractive and inviting entrance facades.

Daylighting – Walls & Storefronts

As well as many contemporary ones…

Great Design Really Counts in the Supermarket Business!

Daylighting – Walls & Storefronts

Don’t forget to control the lights adjacent to the windows!

Great Daylighting Design!

Window walls can have a dramatic effect on the interior space. They also provide a “connection” to the outside.

Great Design Really Counts in the Supermarket Business!

Daylighting – Skylights

Great Design

Skylights can be an effective method of lighting interior spaces – generally in center store spaces.

Benefits include:

- Quality of light
- Quality of store ambience
- Significant energy savings

Membrane roofs and flashing systems are the key enabling technology

Great Design Really Counts in the Supermarket Business!

Daylighting – Skylights

Skylighting Wasted

Skylights can save energy ***only*** if the lights are dimmed or staged partially or fully off during daylight hours.

- We often see lights on full power during the daytime in facilities with full skylighting!

Great Design Really Counts in the Supermarket Business!

Daylighting - Support Areas

Don’t Forget Your Store Employees!

Employee break rooms and store backrooms can benefit from the same daylighting strategies employed in customer areas.

Great Design Really Counts in the Supermarket Business!

Skylighting Cost Analysis

Description	Installed Cost	Electric Rate	Gas cost/yr	Electric cost/yr	Total Energy Cost	Energy Saved	Simple Payback
No Skylights	$0	$0.075	$25,500	$132,000	$157,500	Base	
		$0.10	$25,500	$ 176,000	$201,500		
		$0.125	$25,500	$ 220,000	$245,500		
5'x6' Prismatic double glazed skylights - 4.5% coverage	$168,000	$0.075	$26,780	$112,000	$138,780	$18,720	9.0 yrs
	$168,000	$0.10	$26,780	$ 150,670	$177,450	$24,050	7.0 yrs
	$168,000	$0.125	$26,780	$ 189,330	$216,110	$29,390	5.7 yrs

- Example: Supercenter sales area with standard skylights, national average daylighting and off/1/2 lighting control only
- Simple payback and savings do not factor in energy incentives or financing costs

Great Design Really Counts in the Supermarket Business!

Daylighting

Great Daylighting Design -
Storefront Windows and Skylights:

- Displace all or some artificial lighting to reduce electricity usage
- Provide a superior quality of lighting
- Provide a visual connection between outside and inside and add interest to store front facades

Cautions

- ROIs may be higher than company req's
- Lights need to be controlled in order to gain savings
- Energy modeling required to determine heating/cooling gains and losses and full net energy benefit

Day Lighting	
Exciting and inviting	√
Comfortable and convenient	√
Effective merchandise display	√
Durable and low maintenance	
Reduced environmental footprint -	
Reduced construction cost or time	

Plus save energy, a lot of it!

Great Supermarket Lighting Design

Summary Guidelines

- Have a strategic lighting and daylighting plan that supports the store brand and desired shopping environment.
- Start with a simple lighting plan and then add select/discreet light fixtures only where needed. Avoid complicated lighting schemes.
- Pay a lot of attention to lighting circuiting and control patterns during the lighting and electrical system design process, especially where daylighting is applied.
- Eliminate unnecessary and duplicative lighting for product and signage highlighting.
- Choose lighting systems based on full life cycle costs.
- Include internal case lighting when performing lighting calculations.
- Check light levels using a light meter after the store is built. Then incorporate learning and fact-based decision making into your next store design decisions.
- Control all lighting based on time of day, and on daylighting and demand response programs where available, and make sure it stays controlled.

Great Design Really Counts in the Supermarket Business!

MT Refrigerated Merchandising

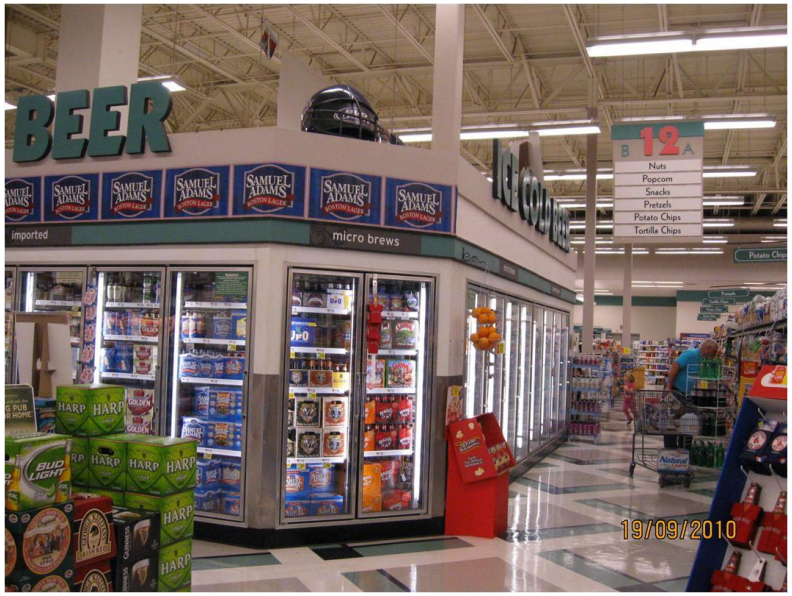
Great MT Refrigerated Merchandising Design

Glass door reachin cases and coolers - they are coming, sooner rather than later now.

- Sales and operating arguments and resistance are breaking down
- Energy/product shrink/sanitation arguments getting stronger
- Best operators will find ways to eliminate down-side effects – stocking labor and sales impacts

Great Design Really Counts in the Supermarket Business!

MT Refrigerated Merchandising



One way past the stocking labor issue – rear feed for all products behind reachin glass doors

Very successful low cost chains adopting this approach for all dairy products

Great Design Really Counts in the Supermarket Business!

MT Refrigerated Merchandising

Cooler-based rear feed glass door reachins already widely accepted for fluid dairy products and eggs, because of sanitation advantages and supplier-loaded rear feed carts and associated labor savings.

Watch out for too low ceilings or poor coil locations in dairy coolers with glass doors – cold air must have free path to area above doors and shelf front facings.

Great Design Really Counts in the Supermarket Business!

MT Refrigerated Merchandising

Glass Door Reach-ins:

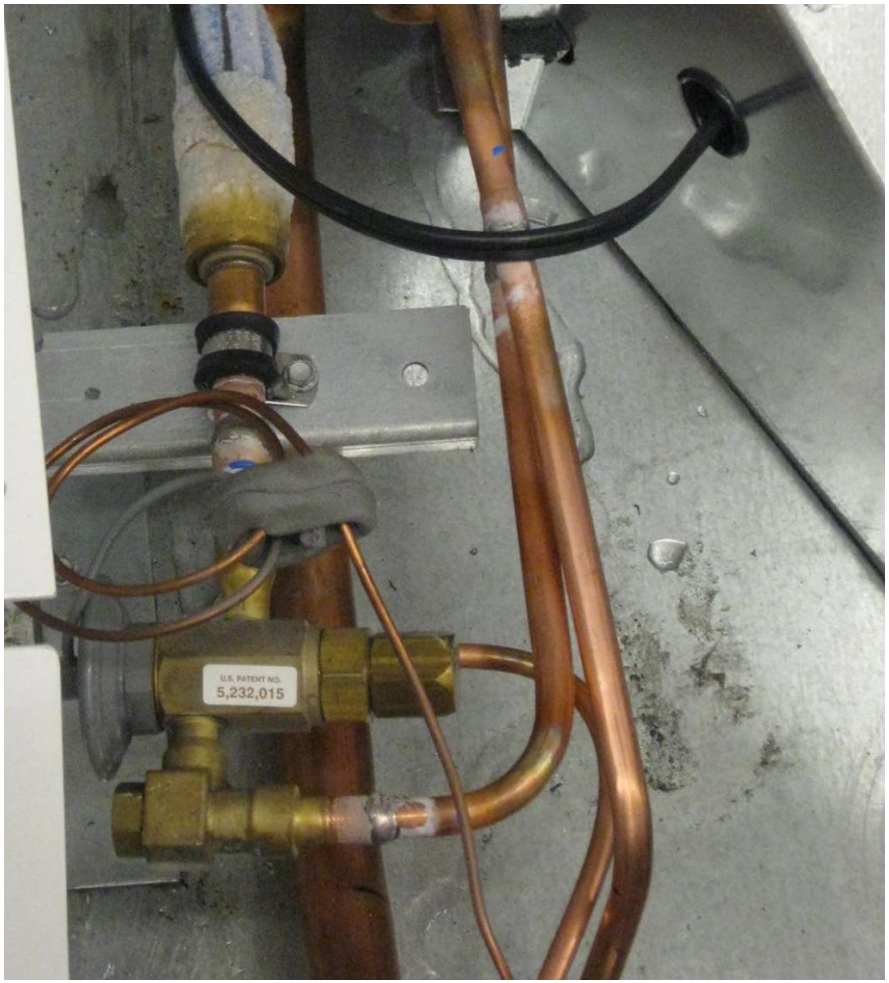
- Provide much more reliable and uniform product temperature than open multidecks
- Reduce returns/shrink/customer complaints
- Eliminate the always intractable cold aisle problem
- Improve illumination of product
- Reachin glass door LED lighting allows further increases in savings, and with motion detectors, even more.

Medium Temp Door Reach-ins	
Exciting and inviting	
Comfortable and convenient	√
Effective merchandise display	√
Durable and low maintenance	
Reduced environmental footprint -	
Reduced construction cost or time	

Plus saves energy, a lot of it!

Great Design Really Counts in the Supermarket Business!

Refrigerant Flow Control



Not-So-Great Design –

Conventional TX Valves

- Difficult (nearly impossible) to correctly set
- Easily plugged with construction piping debris
- Sometimes struggle to control smoothly with POE oils and low liquid temperatures
- Key fixture performance information not available for remote diagnosis of refrigeration problems
- System refrigerant change usually requires valve change

Great Design Really Counts in the Supermarket Business!

Refrigerant Flow Control

Key technology enabler – improved electronics reliability, size, and cost

Great Design –

Electronic Expansion Valves

- Pass most common system debris and rarely plug
- Steady operation even with low liquid temperature and POE oils
- Allow system operation with extremely low minimum condensing temperatures
- Reduce refrigerant leak opportunities
- Accommodate wide range of refrigerant types

Great Design Really Counts in the Supermarket Business!

Refrigerant Flow Control

Electronic Expansion Valves:

- Provide much more reliable and uniform system operation than conventional TX valves
- Eliminate many common system startup and maintenance problems
- Allow remote performance management and troubleshooting of most refrigeration problems

Electronic Expansion Valves	
Exciting and inviting	
Comfortable and convenient	
Effective merchandise display	√
Durable and low maintenance	√
Reduced environmental footprint -	√
Reduced construction cost or time	√

Plus save energy, a lot of it!

Refrigeration System Heat Reclaim

Not-So-Great Design

Conventional hot gas direct heat reclaim!

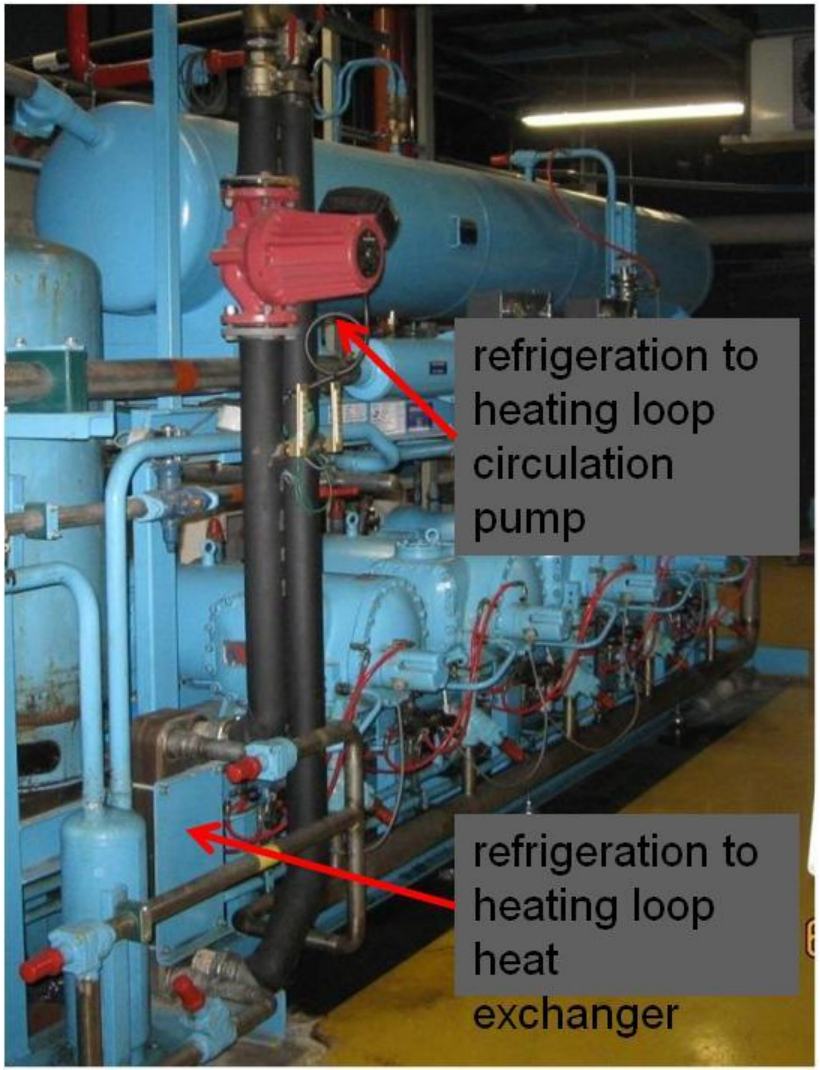
Some discharge side pressure drop unavoidable, adding to high side discharge pressures and energy usage much of the year.

On the other hand, with energy cost and carbon footprint reduction pressures, can no longer continue to just ignore reclaim heat

Huge increase in refrigerant charge, especially in summer when heat reclaim needed for humidity control, to avoid this problem

Great Design Really Counts in the Supermarket Business!

Refrigeration System Heat Reclaim



Great Design

Hydronic refrigeration system heat reclaim!

Reduces reclaim-related refrigerant charge requirement to small fraction of conventional

Allows heat to be delivered any where required within store without refrigeration system discharge pressure penalty

Eases integration with solar hot water and other heat recovery and renewable energy sources

Key enabling technology – low cost welded plate heat exchangers!

Great Design Really Counts in the Supermarket Business!

Refrigeration System Heat Reclaim

Hydronic hot water refrigeration system heat reclaim

Benefits

- Reduction in refrigerant charge – great companion retrofit for R22 changeouts
- Piping system can be low cost thin-walled steel with Victaulic connections
- In real life, large reduction in net energy usage, even with circulating pump energy usage, because of discharge pressure reductions

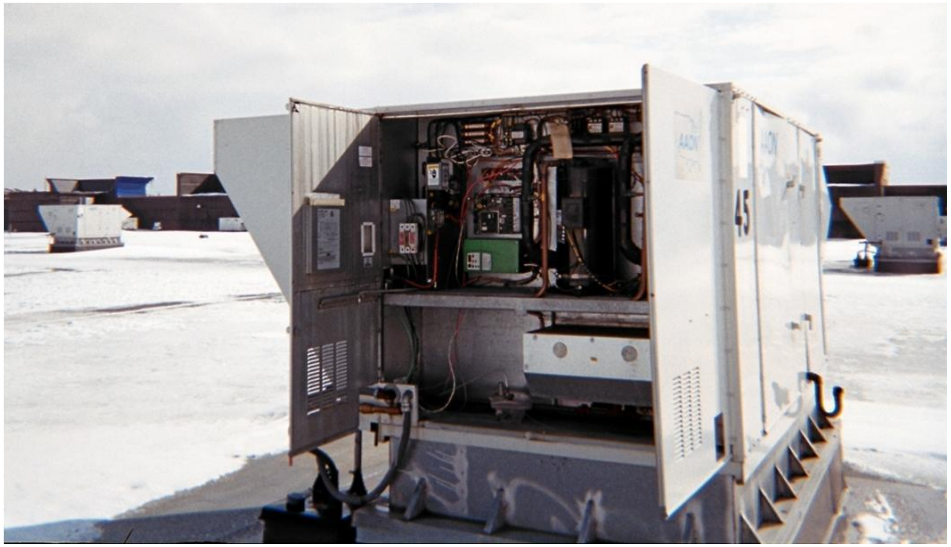
Hydronic Heat Reclaim	
Exciting and inviting	
Comfortable and convenient	√
Effective perishable display	
Durable and low maintenance	√
Reduced environmental footprint -	√
Reduced construction cost or time	√

Plus it saves energy!

Heating and Cooling

Not-So-Great Design

Multiple conventional RTUs with integral condensing units and gas furnaces



Virtually impossible to update heating and cooling appliances as technology improves.

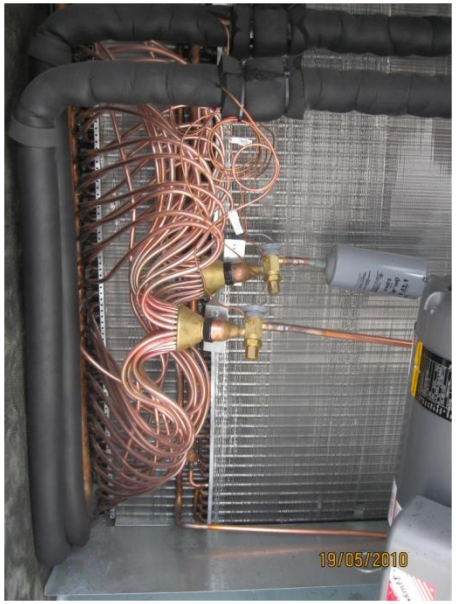
Difficult even to maintain what you have in peak operating condition.

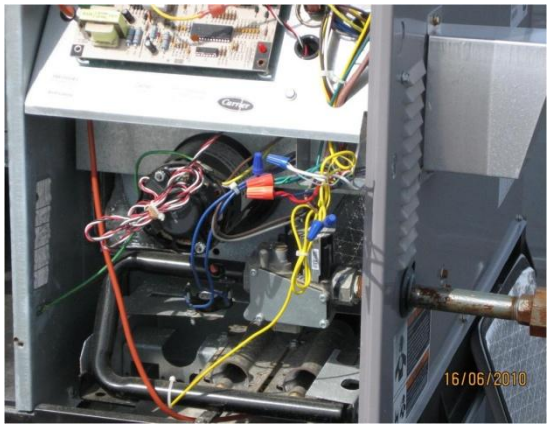
Great Design Really Counts in the Supermarket Business!

Heating and Cooling

Conventional RTU issues

•Noise from condensing unit compressors and condenser fan can be a problem
•Condenser difficult to clean and subject to damage
•Many components to maintain
•Low heating efficiencies





Great Design Really Counts in the Supermarket Business!

Heating and Cooling

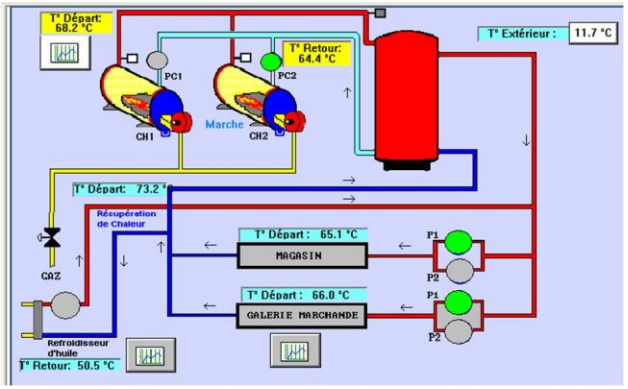
Great Design

Packaged central plant hot/chilled water systems with fan/coil only RTUs!

Reduces refrigerant charge requirement to small fraction of conventional

Allows heat to be delivered any where required within store without refrigeration system discharge pressure penalty

Facilitates integration with refrig. Heat reclaim, solar hot water and other heat recovery and renewable energy sources



Great Design Really Counts in the Supermarket Business!

Heating and Cooling

Packaged central plant hot and chilled water systems with fan/coil only RTUs!

Benefits:

- Higher heating side efficiencies
- Higher cooling efficiencies
- Huge reduction in heating/cooling systems to be maintained
- Upgrade of key equipment can be easily done
- Easier Integration with renewables

Key Enabling Technology – New piping and insulation systems

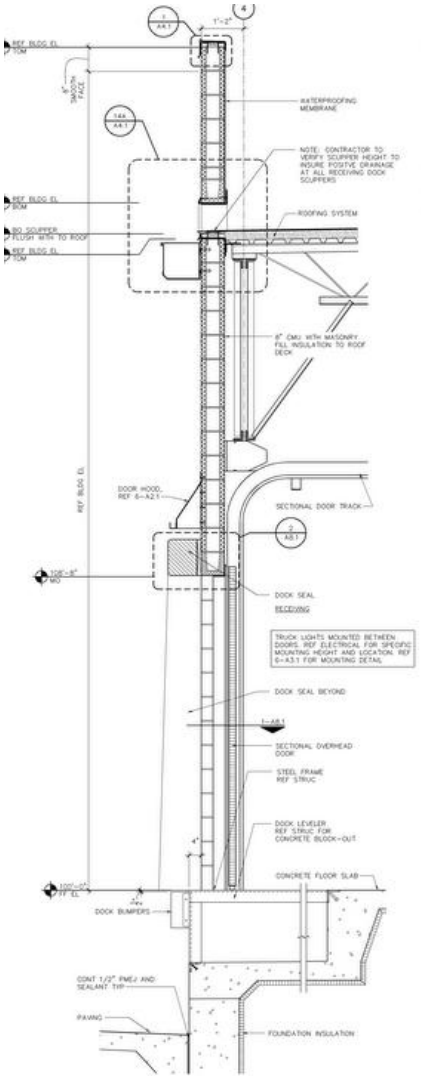
Packaged Central Plant	
Exciting and inviting	NA
Comfortable and convenient	√
Effective perishable display	NA
Durable and low maintenance	√
Reduced environmental footprint -	√
Reduced construction cost or time	

Plus it saves energy!

Building Design - Height

What makes a large space inviting and comfortable?

- The proportions of the interior sales volume (floor space to height) can have a profound and influential effect on the shopping environment.
- Considerations:
  - Excess building height is more costly to build,
  - Uses more construction materials than necessary,
  - Uses more energy to heat and cool.



Find that right balance between too high or too low.

Great Design Really Counts in the Supermarket Business!

Building Design - Height

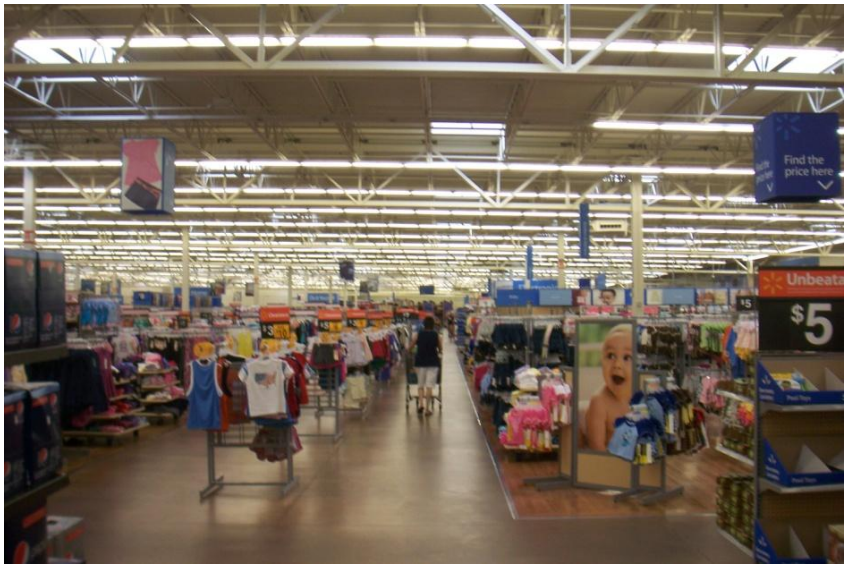
Not-So-Great Design

Too High!

Too much height can create the appearance of an overwhelming and impersonal space.

Great Design Really Counts in the Supermarket Business!

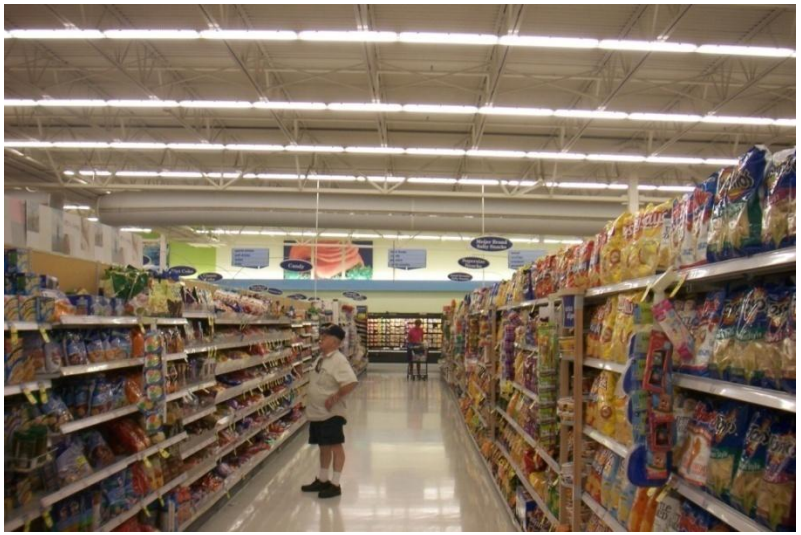
Building Design - Height



Not-So-Great Design

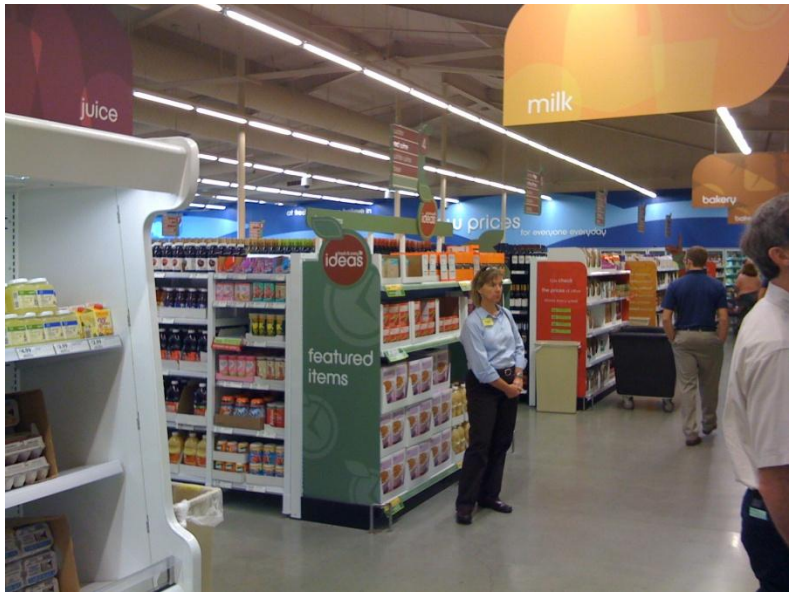
Too Low!

Structures too low can have the opposite effect where the ceiling becomes a dominant element and creates a claustrophobic effect.



Great Design Really Counts in the Supermarket Business!

Building Design - Height



Great Design

Just Right!

Great Design Really Counts in the Supermarket Business!

Building Design - Height

Great building designs (right height) result in:

- Significant building cost savings
- Reduced operating costs for heating and cooling

Reducing the height of a supermarket from 24’ to 22’; for a 50,000 ft2 building = construction cost savings in excess of $25,000 and a 10% reduction in HVAC load, forever.

- A more comfortable and inviting space
- Diminishes box height and volume as the dominant store environment feature – allows more focus on the product

Proper Building Height	
Exciting and inviting	√
Comfortable and convenient	
Effective perishable display	N/A
Lower maintenance	√
Reduced environmental footprint -	√
Reduced construction cost or time	√

Plus save energy

Great Design Really Counts in the Supermarket Business!

Building Height

Height Guidelines

- Reduce building height to lowest practical limit, but also be aware of impact of perceived low height on shopper experience.
- Be aware of proper building proportions for a comfortable building volume. Height/width/depth dimensions are important to a properly sized volume.
    - Lower ceilings/roofs are more appropriate on smaller buildings.
    - Larger buildings generally need taller ceilings/roofs.
- Consider alternatives to mezzanines and high rear storage that can drive height of overall building.
- Consider 1/8” roof slopes rather than 1/4” standard.

Building Size

Not-so-great design

Too much empty space

Great Design Really Counts in the Supermarket Business!

Building Size

Great design

Comfortable shopping – not too congested, not too empty

Great Design Really Counts in the Supermarket Business!

Building Size

Optimized Building Size

Scrutinize and challenge square footage, clearances, aisle and drive aisle width.

- Are you designing for a few, very busy days of the year? Size for 90% of busiest day, not 99%.
- Not all aisle widths need to be the same. Vary widths based on traffic density.
- Why is an urban store that is smaller and more dense acceptable, but the same store in a rural or suburban is not?
- Are you building now for a distant future pro forma sales number?

Optimized Building Size	
Exciting and inviting	
Comfortable and convenient	√
Effective perishable display	N/A
Lower maintenance	√
Reduced environmental footprint -	√
Reduced construction cost or time	√

Plus it saves energy!

Conclusions

- Truly “Great Design” results in many benefits, including energy efficiency.
- One can argue that today, no design, no matter how architecturally clever or attractive, or how well it meets other design goals or needs, **can be considered “great” if it increases energy usage above the lowest level practically achievable**.
- **Where conflicts between energy efficiency and sales and other basic business goals result from design choices, it is our responsibility as professionals to identify/create new, alternate designs that eliminate those conflicts while achieving the same, lowest possible level of energy usage**.