IMPACT OF RETAIL STORE DESIGN UPON PRODUCTIVITY

ENERGY EFFICIENCY

by

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Gas, coal, oil, and nuclear fuels are used today for the generation of electricity. The economic costs of these fuels all very directly enter into the price one pays for electricity. The supermarket industry uses approximately 85-92% of its total utility costs for electricity while heating fuel is a factor of 8-15%.

A breakdown of electrical usage for a market on an annual basis is as follows:

Refrigeration	55-75%
HVAC (Heating, Ventilation, Air Conditioning)	12-15%
Lighting (Interior & Exterior)	18-25%
Remainder of Store	8-12%

Percent of total electric dollar by department would be as follows:

Low Temp	26%
Meat	12%
Dairy	10%
Produce	7%
Lighting	23%
HVAC	14%
All Other	8%

Much of the overall electrical usage could be minimized with proper designs of a market. Proper designs must include sound merchandising capabilities, sound operational capabilities, good equipment selection, good maintenance capabilities, and sound efficient energy usage.

The energy usage is what I am going to relate to today. Proper design from an energy standpoint must begin with the set of design requirement specifications and drawings that the store owner or chain supplies to his architect. In these documents, the owner outlines the specific requirements that he has for his building. Specific requirements such as the amount of insulation he must have in his roof, the design criteria for his HVAC (heating, ventilation, air conditioning) system, the electrical distribution system, the type and layout for his lighting system, etc.

Roof insulation should be of a magnitude that a U factor = 0.06 should be accomplished. U is a measure of resistance to heat transfer. It is a well known fact that the majority of heat transfer into a building during the warm summer months is transferred through the flat roof surface and likewise the heat transferred through the roof. To sum it up, the heat always goes to the coldest location. Therefore, it is economically sound to spend more dollars up front to insure that a good insulation amount, a good vapor barrier, and a good roofing material be used on a new building.

The structure should basically be divided into three main areas: the sales area, the prep areas, and the backroom areas. Each area should be sealed off from the others as much as practical. Let's explore the sales area first. It is known that the humidity content of the area surrounding the refrigerated sales equipment has a significant bearing on the electric load that piece of equipment uses. The refrigerated equipment requires 75^{o}F dry bulb temperature and 55% relative humidity to operate effi-

ciently. When either the humidity or the temperature goes up, so goes the electrical usage of the equipment. Likewise, when either of the two factors goes down, so goes the amount of electrical usage also within certain limits. It is therefore critical that the temperature/humidity criteria be met and/or exceeded in order to maximize the efficiency of the refrigerated equipment (which we have learned is 55-75% of the total load in a store).

When the sales area is basically sealed off from the rest of the store, then the only avenue for external air into the sales area is through the front end doors. This is controlled by the properly designed HVAC system that incorporates approximately 10% make up air from the exterior and discharges approximately 75% of the total air in the front third of the store. Also, having a vestibule between an inner and outer set of automatic doors with an air discharge grill located between these doors (discharging pressurized air) will help minimize the infiltration of untreated exterior air.

The prep areas should be isolated from the rest of the store because as a rule, these areas are air conditioned. Let's take a look at the meat prep area. This area is traditionally kept at 50-55°F with low relative humidity. The reason for this temperature is that bacteria count goes up on the surface of the cut meat exponentially as each degree of temperature is added. Ideally, cutting rooms should be kept closer to 32°F. However, getting people to work efficiently in that reduced temperature atmosphere is a major problem and so the 50-55°F range has been established. Surrounding this structural envelope is the sales area on one side which is at 68-75°F and the back room areas on the other three sides which are at 60-90°F. To minimize the heat transfer into the prep area, it is imperative that the ceiling and walls be insulated, and therefore minimizing the energy used by the refrigeration system cooling that room.

Produce prep areas are also air conditioned many times but not to the extent that the meat prep area is conditioned. However, the ceiling and walls must be insulated properly also.

The bakery prep area, which has heat producing ovens, proof boxes, heavy mixing equipment, etc. is not economically feasible to air conditions because of the magnitude of the heat added to the room. It is usually best to establish ventilation in this area with air supplies from the exterior. In other words, have an exhaust fan, and a direct supply of air ducted from the outside which will cool the room.

The deli prep area may or may not be air conditioned depending on the activities that are performed. Heat producing items such as deep fat fryers, bar-b-que units, stoves, etc. add too much heat load to effectively overcome with air conditioning. A system of exhaust similar to the bakery prep area is called for in this case.

Let's turn our attention now to the properly designed HVAC system for the sales area of the store. The primary reason for the magnitude of air conditioning in a store is not as you might suspect, for customer comfort. But, is for establishment of proper ambient (surrounding) air to the refrigerated equipment. Customer comfort is secondary to the refrigerated case operation. Therefore, it is desireable to use whatever cool air that is spilled from the refrigerated equipment. Actually, this spilled air is quite extensive as you know from your visits to supermarkets and the cold aisles you experience while walking by the open multi deck freezer or multi deck dairy cases. I have measured temperatures of 55-60°F in these aisles during the heat of summr. You might say that is good temperature around the case which should add to the efficiency of the unit. Wrong! Various temperature ranges of refrigeration systems (high temp. 65-75°F, medium temp. 30-40°F, low temp. -15 to 0°F for examples) have different effi-

ciencies as far as the number of BTU's (British Thermal Units) they remove from the air. Examples are air conditioning (high temperature, 12 BTU/watt), meat, produce, dairy cases (medium temperature, 7-9 BTU/watt), frozen food, and ice cream case (low temperature, 4-6 BTU/watt). What this says is that the lower the operating temperature range, the fewer the BTU/watt used in removing heat from the refrigerated case. The multi deck freezer falls within the 4-6 BTU/watt range and the multi deck dairy falls within the 7-9 BTU/watt range. It is far more efficient to remove the heat and humidity from the aisle in front of the cases by using the store air conditioning which operates at the 12 BTU/watt range.

The HVAC distribution system must be properly designed. We have already stated that upwards of 75% of the air should be discharged at the front third of the store. To get the air down to the 0-7 foot height which is the area of the store you are most interested in air conditioning, is the next part of the system design. You do this by designing the air return to the HVAC system low in height, preferably under the refrigerated cases. This also accomplishes mixing in the spilled-over refrigerated air from the cases. The cool air from the cases means that a credit to the overall air conditioning load can be given and therefore less capacity and running load may be accomplished.

Let's now talk about the heating portion of the HVAC system. In most systems, the heat is accomplished by electricity, natural gas, oil, propane, etc. The refrigeration equipment throws off a tremendous amount of heat into the atmosphere. By taking this refrigeration system waste heat and channeling it into the heating system, we can likewise take a credit for so many BTU's of heat and therefore need less heating equipment and less operating cost. This "heat reclaim" of originally wasted refrigeration system heat is almost "free."

You must purchase and install the piping and heat reclaim coil, as well as experience somewhat higher electrical costs to operate the refrigerated equipment. However, a soundly designed heat reclaim system is a must in today's economy. In the event of another fuel shortage such as we had several years ago, this might be the only means of keeping your market open.

The electrical distribution system is the next area in the store design that you should address. Use no aluminum wire. In spite of the power companies extensive use of aluminum wire, it is recommended that the physical characteristics that this medium has make it undesireable for installation in a supermarket. Oversizing the wiring throughout the system to minimize "heat" losses is also sound practice.

The store lighting system is an area that is not understood by many people. The lighting level in a store is primarily designed for merchandising reasons. The object of the light is to highlight certain merchandise as well as provide a run-of-the-mill lighting level for other merchandise. The ratio of highlighting to ambient (surrounding) lighting should be in the vicinity of 150%. This means that if you have a 100 foot candle lighting level and you want to highlight something in that area, you need a lighting level of 150 foot candles. The multi deck refrigerated cases come with their own lights installed which adequately provide for merchandising capability. The darker the ambient (or surrounding area), the greater the highlighting in the multi deck refrigerated cases. In those aisles where there are cases and/or shelving fixtures opposite one another which have their own lights, then there is no need for ceiling lighting over those aisles. This will highlight the product in those fixtures to a much greater degree.

Lighting is a very subjective type item. There are several lighting sources for the sales area. They are bare fluorescent strip lighting, recessed fluores-

cent lighting, ceiling mounted H.I.D. (high intensity discharge) lighting (mercury vapor, metal halide, high pressure sodium), combination HID lighting mounted on gondola tops which reflect off the ceiling. Which system you choose will be dictated by the quality and quantity of lighting the owner wants.

Recommended illumination levels in foot candles is as follows:

Overall sales floor	80- 90
Meat cases (highlighting)	110-150
Refrigerated cases	110-150
Coolers	10- 15
Gondolas (with lights)	110-150
Front end	80-130

The refrigerated equipment one has in his market is generally dictated by several factors: namely merchandising and operational capabilities. However, there are new energy usage factors which are entering into many equipment selections. The overall objective is to provide adequate merchandising of the various products along with an economical operating cost of ownership. We have already seen that the greatest percentage of the electric dollar goes for frozen food equipment. Which case do you purchase? Is it single deck well type coffin cases, or is it glass door reach-in cases, or is it open multi deck cases? The cost of operating these various pieces of equipment increases as they were presented: coffin cases, reach-in cases and open multi deck cases. Each case can serve a different function. It is ordinarily recommended that a combination of this equipment be used. The open multi deck cases for the fast moving items; and the coffin cases for ice cream; and the reach-in cases for the slower moving items. This is a possible mix and match, all of which is dictated by merchandizing with energy considerations.

Which condensing units do you use? is another question that must be asked. There are individual condensing units for individual cases; individual condensing units for strings of a specific case; three unit parallel for multiple strings of cases; or four unit parallel systems for multiple strings of cases.

The most economical cost of ownership must be weighed as to which system you choose.

The next area to be explored is that of the energy management system. Because the technology of these "black boxes" as they relate to supermarkets is in a state of flux, the most economical means of handling this situation in a new store is to equip the structure with adequate wiring during the initial construction so as to be able to handle most any situation. What this means is that you build into the initial wiring design low voltage wiring to each refrigerated case. Ordinarily, six pairs of shielded stranded wire should be used. The reason for six pairs is to have adequate wires for whatever function you might want to perform plus an extra couple of pairs. These wires should all be brought back to some location in proximity to the compressor area.

The features of an energy management system could be as follows:

1. Demand (Power) Load Leveling Control which includes failsafe control which can prevent the demand from exceeding a predetermined set point by turning off specific equipment using a defined time interval.
2. Time of Day Scheduling Control which includes capability of scheduling specified loads "on" and "off" once or twice in each 24 hour period. Scheduling for each day of the week for each load as well as scheduling each load for holidays is included.
3. Refrigerated Case/Cooler Temperature Control which includes control of refrigerated case and cooler temperatures by establishing high and low temperature set points for each case, cooler, or preparation room thereby maintaining the temperature between the set points. Also, alarm initiation if the temperature in any refrigerated case, cooler, or prepara-

tion room exceeding the designated set point.

4. Environmental Control which controls in-store heating, cooling, ventilation, and dehumidification.
5. Anti-Condensate Heater Control which controls anti-condensate heaters based upon the dew point of refrigerated case surfaces exposed to refirgerated air, indlucing glass doors on reach-in cases.
6. Refrigeration Defrost Control capable of controlling defrosting a specific number of refrigeration systems. Each system should have the capability of defrosting eight times daily with a duration of 5-90 minutes.
7. Demand Defrost Control which cancels normally scheduled defrosting when the frost build up on the refrigeration coils is not sufficient to warrant defrosting.
8. Alarm Features which is composed of an in-store and remote alarm notification for unsatisfactory high and low case temperatures, in-store high and low ambient store temperatures, high in-store relative humidity, designated equipment malfunctions, and power failures.

Each of the above could be effective features of an energy management system.

Which of the energy management systems features do you include? This is to be done on a basis of R-O-I per feature. In other words, an analysis must be done which evaluates each of the features for a specific structure and the cost of the anticipated savings vs. the anticipated cost of each feature.

In a very brief period of time, an effort has been made to expose you to some of the design considerations. I think you can see that there is a tremendous amount of information that must be evaluated during the design stages of a supermarket if energe usage is to be minimized and used efficiently.

Thank you.