A New Approach to Monitoring Energy and Optimising Cold Storage Costs

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FJB Systems provides design and project management services for the food industry, covering business plans, process layouts, architectural planning drawings, design drawings and specifications for all aspects of a project.

We have a particular specialist knowledge of refrigeration design and the optimisation of energy costs and the monitoring of them using FJB Systems' recently developed software package.

Typical Cold Storage Operating Costs

The following provides a back-drop to the question of how important energy consumption can be, based on a cold store of approximately 1 million cubic feet with freezing tunnels:

Operating Costs per annum

		% of total
Rates	£50,000	13.70
Personnel	£160,000	43.84
Stores	£10,000	2.74
Electricity	£100,000	27.40
(NH_3) System (pumped)		
Maintenance	£30,000	8.22
Misc. Expenses	£15,000	4.10
Total	**£365,000**	**100%**

Finance Charges per Annum

Depreciation (15% pa)	£450,000
Interest at 7%	£210,000
Total	**£660,000**

Table 1 - Typical operating costs per Annum - 1 million cu.ft. store

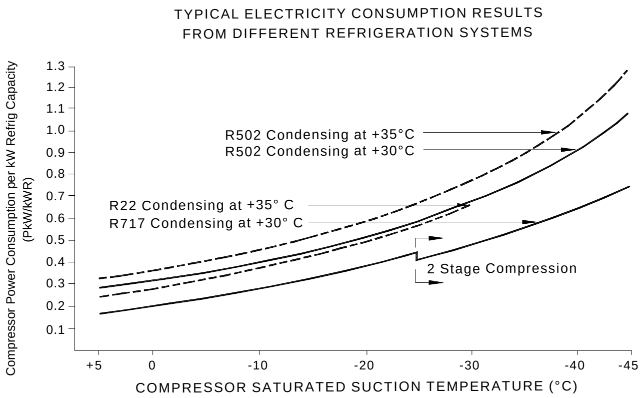

Figure 1 - Compressor energy consumption of different refrigeration systems

Even with a reasonable labour content as shown, the electrical consumption of the refrigeration plant represents some 20-30% of the typical operating costs. Refrigeration plant efficiency is therefore exceptionally important to ensure a competitive operation.

Selection of Refrigerated Systems

The choice of refrigeration design must be made between the following systems:

1. Decentralised direct expansion "Freon" systems
2. R22 (or substitute)
3. R134A, R404A or R407C
4. Centralised pumped refrigerant system
5. NH_3
6. Centralised NH_3 system with secondary pumped refrigerant (Glycol)

For larger plant serving large cold stores, it is essential that a centralised pumped system should be employed. The above graph explains way:

The graph shows typical compressor energy consumption figures for single stage R502 plant and compares these figures with an industrial pumped NH_3 system. R502 is now being phased out, but substitutes now available such as R404A and R407C exceed these R502 energy consumption figures. Such "Freon" refrigeration systems are usually built using air cooled condensers for as little as £500/kW refrigeration installed compared with a pumped NH_3 system at around £800/kW. However the DX plant will condense at a temperature with air cooled condensers at least 5^{0}C higher than an NH_3 system or R22 system, with evaporative condensers. Thus, with a plant designed to operate at -40^{0}C suction pressure, the pumped NH_3 system will consume some 0.62kW electrical compressor consumption/kW refrigeration output compared with approximately 1.07kW/KW for the low first cost DX system. For the serious cold store operator, this is simply unacceptable. The following table summarises the approximate cost implications for a 1 million cu.ft cold store, operating with freezing tunnel.

System	Capital Cost	Electrical consumption at -40 ^{0}C	Typical store electricity cost/year	Typical store refrigeration capital cost
Freon/DX	£500/kW	1.07kW/kW	£172,580	£250,000
Pumped NH_3	£800/kW	0.62kW/kW	£100,000	£400,000
NH_3 Glycol	£880/kW	0.75kW/kW	£120.968	£440,000

Table II - Centralised/Decentralised plant cost comparisons

It can be seen that the electricity costs each year will be higher by some £75,000 with the lower installed cost DX plant. The NH_3 Glycol system should only be used if the operator is forced to abandon a pumped system due to alleged safety reasons.

If we now review these increased electrical consumption figures applicable to small multiplant room DX "Freon" systems to the operating cost data for a similar cold store as shown in Table II, the additional £75,000 in electrical costs per year represents an increase in the total cold store operating cost of some 20%. This means that to break even, this higher electrical cost will require a 20% higher storage or freezing charge than competitor stores with well designed centralised pumped NH_3 systems.

Typical Refrigeration Loads

Once a store is operating, it is necessary to monitor individual cold storage rooms or freezing tunnels for energy consumption to ensure energy efficient operation is achieved.

The following figures show typical heat loss allocations in a low temperature room:

Insulation losses	48%
Change in air losses (1/4 air change/hr)	36%
Other loads	16%
Total	**100%**

It will be noted that some 36% of the refrigeration load is imposed by door openings on the basis of 1/4 of an air change per hour. If door opening become excessive, then at 1/2 an air change per hour the air change element increases to approximately 50% of the total refrigeration load and the total itself will increase by some 35%.

Thus it is important to have a system to monitor refrigeration energy consumption related to individual complex storage rooms if economical operation is to be maintained.

Monitoring of Refrigeration Energy

Electricity monitoring for individual packaged "Freon" plant is relatively easy by fitting kW hour meters to each unit which then measures efficiency of operation for the room that the individual plant is servicing.

However, for individual room monitoring for a large cold storage complex operated by means of a centralised pumped refrigeration system, monitoring is not so easy. The total refrigeration energy consumption can be easily measured through meters on the plant room but whether cold storage rooms are operating inefficiently is difficult to determine.

FJB Systems have developed such a monitoring system which is operating effectively in a large UK cold storage complex.

Basis of Monitoring System

Our software package assesses the time that each evaporator liquid solenoid valve remains open during the monitoring period. Monitoring also takes place related to the operation of each individual evaporator fan.

This continuous information is then related to each evaporator surface area of the complex through the software system and then splits the total plant room electrical consumption figures proportionally between the

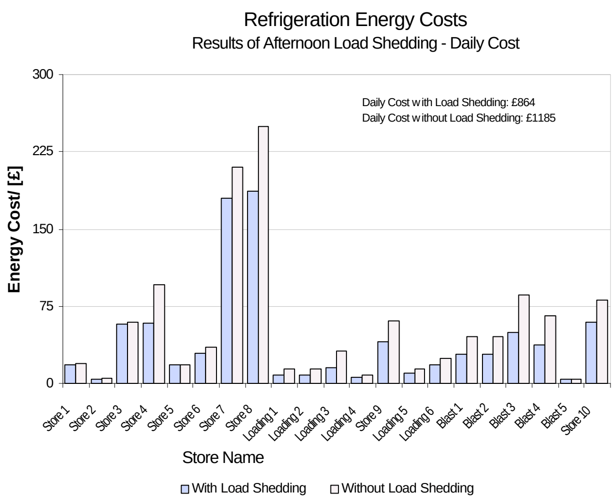

Figure 2 - Room costs - with & without load shedding

cold store rooms of the whole complex. The information is also weighed relative to the refrigeration circuit that the particular room is using.

High temperature circuits with higher machine suction pressures have a lower weighting than low temperature circuits. A room operating on a -40^{0}C evaporated temperature system will consume approximately 2.5 times the electricity for a similar refrigeration loading than the same room working with a -10^{0}C system. The whole procedure is somewhat more complicated than this but is based on these principal basic elements.

The histogram chart (Fig.2) shows typical daily refrigeration energy costs for each room of a large cold storage complex comparing room costs with and without load shedding:

The ongoing monitoring can assess cost changes relating to different temperatures held on the loading bank or indeed savings than can be made by simply holding higher room temperatures. The graph (Fig.3) shows the maximum demand reduction on the incoming electrical supply due to load shedding over a high tariff period. It also shows the demand that would have been applicable without the load shedding procedures being introduced.

Figure 4 shows a typical summary of a site energy cost. The very high cost attributable to lighting is of particular interest.

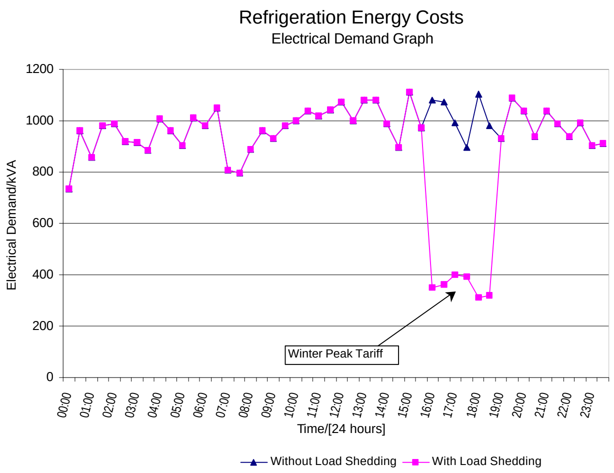

Figure 3 - Maximum demand with load shedding

Summary/Conclusions

Refrigeration energy costs for a large cold storage complex can represent some 20-30% of total operating costs, which means that storage and freezing rates offered to clients become competitive, dependent upon efficient refrigeration system design and cold storage operation.

Thus monitoring of individual storage rooms and freezing facilities is important to determine door losses and other operational inefficiencies. Such monitoring is easy for refrigeration systems which work on individual rooms. However, such decentralised plant can in itself increase electrical consumption by some 70-100% compared with centralised pumped systems.

FJB Systems have developed an energy monitoring system for centralised plant which through a software package will provide daily energy costs for each room in a large complex. Load shedding can be added to the system and the cold storage management will have an effective tool to reduce energy consumption. We believe this is the first time such a system has been fully implemented and its use will allow management to monitor performance and reduce operating costs, which is becoming important with industry energy taxes being introduced into the UK.

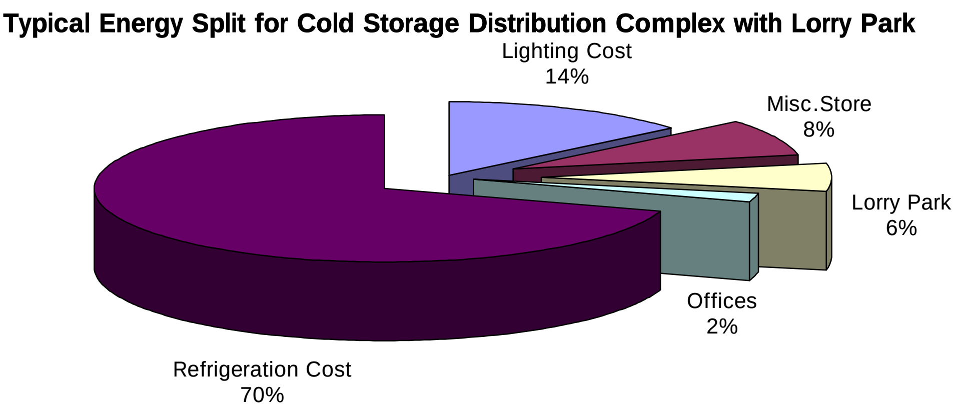

Figure 4 - Site Energy Cost Summary