Cooling awards 2012

For Arctic Circle

Applied UK

&

James hall & Co ltd

Spar store Sedbergh

Background

The project was to build an environmentally acceptable store within the Lake District national park upon the site of an abandoned livestock auction mart in the rural village of Sedbergh. The site was to be jointly occupied by a 3000Sq Ft convenience store and a local health centre. Whilst the planning permission would be two separate applications both sites had to conform to a combined aesthetic strategy and the store had extra conditions placed upon it.

The initial application was rejected in 2007 and again rejected in 2008 this rejection by local and regional planning authorities prompted such a public interest in the for and against campaign that a public enquiry and subsequent hearing was set up for 2009.

At this hearing assurances were made to the planning authority both local and regional regarding the construction and despite lobbying by Rural England, the national parks, and the Yorkshire dales campaign body planning was with caveats granted in 2009

Construction began in 2011 and the aim was to open in late 2011 or early 2012.

Brief

To enable to meet and in some cases to surpass a number of the planning requirements it was decided at an early stage to make this store a trial store for major new technologies which are available. As James Hall is the trading and master franchise holder for the north of England Spar brand the ability to construct a beacon store for all of the franchise holders to view would be would be an invaluable asset in bringing new and environmentally friendly technologies to the small man in the corner store and allow him to see how new technology can not only reduce his operating cost but also the overall life cycle cost and help in understanding this technology in a true and relative application, the following technologies were to be included.

- Photo voltaic
- Co2 heat pump water heating
- Lighting control

- LED lighting (back of house only)
- BMS control
- RDM refrigeration control
- Free cooling (air conditioning)
- Doors on dairy cabinets
- Chilled water dairy cabinets
- Heat re-claim
- Hydrocarbon main refrigeration plant providing chilled water (Arctic Circle free-heat)

Integration

Application of new technologies are in themselves a useful tool for the reduction of Co2 emissions but simply installing these without suitable integration will not give the optimum results , but as the final object of any exercise within a store selling food items the relationship between food and new technological applications must not be overlooked.

The integration first took the form of capturing the heat from the refrigeration system, but heat reclaim for heat reclaim sake can actually be costly if tight controls on the actual condensing pressure are not maintained this issue was solved by three methods.

The first was to recapture heat from the refrigeration system and in low ambient conditions reject this directly to an under floor heating system. As the store is in a remote hillside village which will experience harsh winter conditions this is an excellent way to re capture low grade heat in opposition to using normal air sourced heat pumps which in low ambients exhibit considerable efficiency loss below -5 deg C. The store has a unique selling point which is the construction of a beer chilling room which is open to the public (see photo) this room open at both ends combined with a high lighting load presents almost 10kw of continual load to the equipment.

The total calculated duty of the store is 30Kw of heating and the based upon a 4 month heating cycle operating between November and February and taking into account degree days in these periods we have approximately 96 days heating for 8 hours a day

With a total heating requirement of 30Kw and a mean COP of 4:1 there would be a total energy consumption if using standard split systems of :-

8.1Kw x8hrs /day x 90 days = 5832Kw

It must be noted that the store is open 07.00 – 11.00 and the 8 hours accounts for the cycling of the equipment as continuous running would not happen.

5832kw which has been saved at this point. We must now deduct the circulating pump which is inverter driven and the average consumption was recorder at 2.6kw /hour for the heating period which gave a total energy consumption of 1872kw giving a projected saving of 3330 kW in this period.

To offset any loss due to secondary refrigerant and pump power absorbed a total of 10KW of PV panels have been installed

Once the store was at set point temperature the second application of the rejected heat was initiated. The store has two deli food areas supplying both hot and cold produce including cut meats, hot chickens and freshly made sandwiches. Such an operation has a high hot water use for washing down.

Raising water from the mains to 65 Deg C is a costly business especially when the average incoming water temperature is 6 deg C all year due to the exposed nature and the granite substrate of the area.

To conserve energy the water is passed via a pre-heat tank which is in series with the main water tank which is heated to 65 Deg C by a Sanyo Co2 heat pump water heater this is ideally suited for such low ambient conditions as the lake district.

With a water usage of 900ltr per day the reclaimed heat raises the mass of the pre-heat tank to 40 Deg C which has a volume of 300ltr the savings are the difference as below raising the water by 34DegC with no penalty in head pressure in summer

Q = Mass x SpHt x TD

Q = 300ltr x 4.2kj/kg x 34 Deg C

Q = 42.8 Kw three times per day

Total saving of 128.4 kW prior to entering the Co2 tank as a pre heated medium.

This lift in temperature means that the Co2 water heater has only to lift the water 25 DegC and with a conservative COP of 3:1 the total energy use is dramatically reduced, to 31.5Kw as opposed to 94.5kw if electrical resistance heating is used.

If the preheat tank was not in place and the Co2 water heater was to take the full load the total energy used would be, based upon the above COP 75.6Kw

The final aspect of the integration is that the over door heater, can if sized correctly (by increasing the size of the unit and hence the coil to accommodate the lower water temperature) provide a suitable air off temperature to reduce heat loss from the building. The standard over door heater is rated at 12kw for double opening doors and this was removed by the installation of an oversized door heater using 40 Deg C water to give an air off of 30Deg C

This was seen to give an average saving of 52 kW / day in running cost during the low ambient period compared to a normal store. The heater is operated via an external sensor and controls a valve to provide automatic operation.

Free cooling

During the periods of early spring the solar gain experienced by a building can be quite high whilst the ambients are relatively low, indeed the average nightly temperature after sunset is only 7 to 14 Deg C dependent upon the season with an average all year round temperature of only 11 deg C the

ability to use ambient air for cooling is a great advantage. To facilitate this AHU was positioned within the store room of the shop at high level and supply ductwork was positioned to give best air distribution. The system can modulate from full fresh air dependent upon external ambient to full recirculation in the heating mode to reduce stratification. To assist the cooling effect the fresh air is taken from the north side of the building in a shaded area to obtain maximum cooling effect. To ensure that the store in high ambients is cooled sufficiently a glycol cooling coil was installed in the AHU and interconnected to the chiller. The design duty for the cooling coil is 30Kw with a fan of 5.5Kw. In the 8 months of operation the store has only used the glycol cooling facility for a total of 44 hours relying for all necessary cooling on the FAI system.

Chilled water & cabinet selection

It was the intention of the design to reduce the environmental impact this store would have and to this end it was decided that a chilled water and hydrocarbon system would be the optimum installation. The reason for this is that, this design has to address the environmental issue and keep the cost and technology within the grasp of the small end user with high reliability. The design and its derivatives can be sold to the smaller end of the market and the independent convenience store operators as a viable long term solution with comparable maintenance cost to existing DX systems, Co2 is out of the reach of all but the big multiples and Nh3 is a non starter, this is a design for the people to help them embrace a new technology with an old idea.

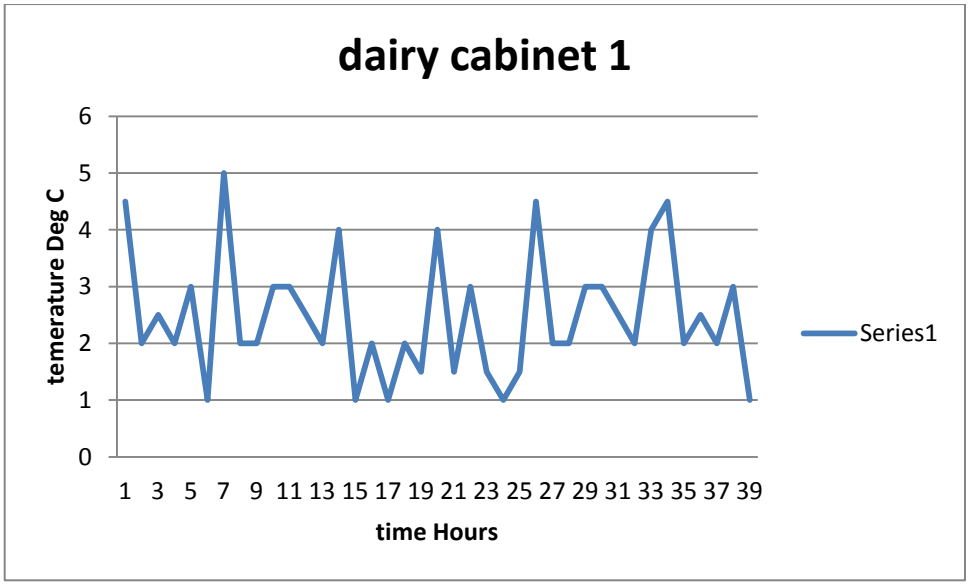
The chilled water allows all refrigerant to be kept in one area and to reduce the charge of a system to less than 40Kg. it was however extremely difficult to obtain accurate data for cabinets operating on chilled water and having double glazed glass doors fitted, after initial work with the cabinet manufacturer it was decided to increase the cabinet coil size to the maximum calculated load and then add some 25% to this duty for specific reasons which we detail later.

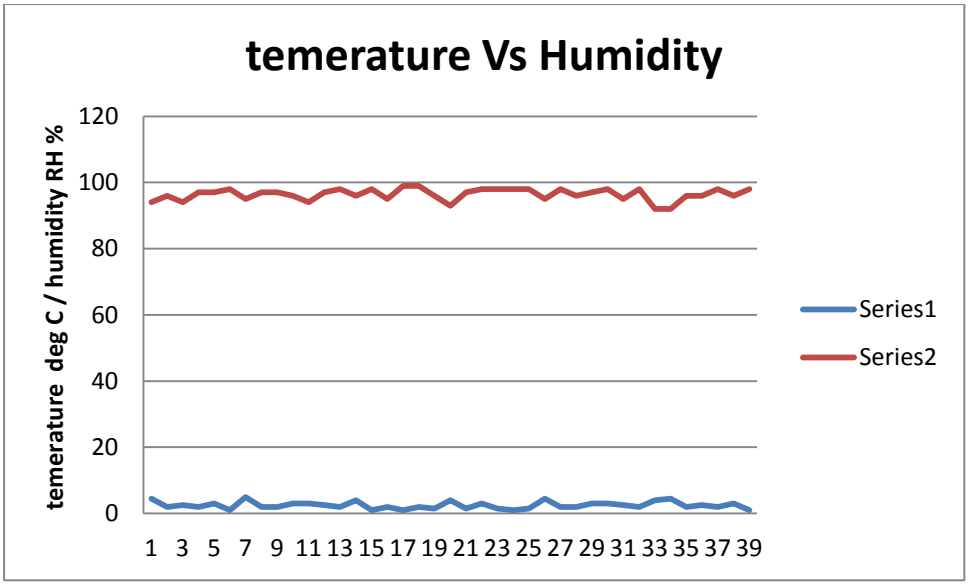
Any convenience store has a large reliance upon the fresh range of produce it has for sale and whilst as engineers we consider the impact of the environment by how many Kg of carbon we discharge in to the air do we ever consider the cost in land fill and extra transport of products to replace the ones that are discarded. This may not be a large amount when in the context of the big multiples but in the realm of the independent retailer this is a big issue.

Our aim was simple reduce the waste and increase shelf life of fresh foods naked and wrapped. Three things will affect shelf life of product, exposure to light, thermal shock, and humidity, two we can deal with directly if we design the cabinets correctly. One of the main causes of shock is air movement affecting the temperature of the cabinet; to combat this we installed doors. The other is defrost cycle in relation to evaporating temperature. The larger coil and extended surface area allowed the glycol temperature to be increased from design of – 6 Deg C to -1.5 Deg C. The thermal mass of the coil enables a defrost to be achieved slowly and the increased size allows less moisture removal, as a result product waste is down and yield is up. As can be seen from the graphs at no point is the cabinet above 5 Deg C and the RH is an average of 97%.

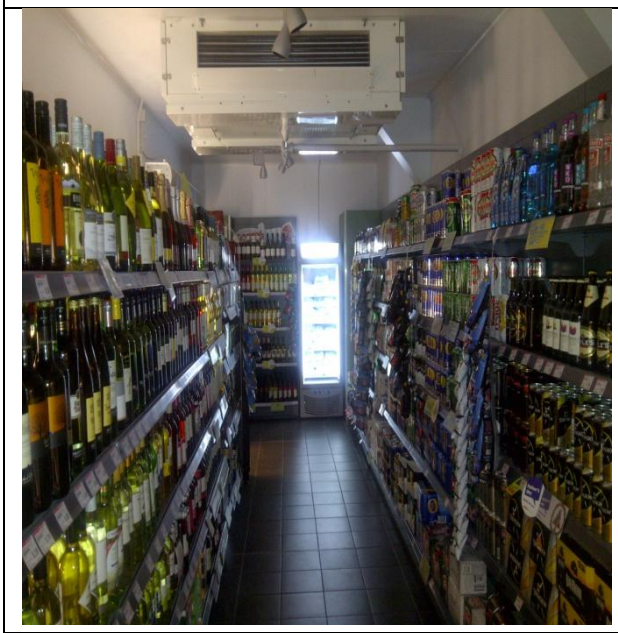
As initially detailed this store is a beacon and the lessons learned from this can be carried further and modified to suit all sizes of convenience store 1000Sq Ft to 3000sq ft. We believe that this store

and designs based upon this store will set the standard going forward for the convenience market by educating the 4500 independent store operators in the UK to a new way of thinking bringing efficiency and equipment longevity to the masses in a way no other environmentally friendly design can do and for showing the way to the rest of the small food sector. From our understanding this store has the highest energy efficiency rating of any independent food and convenience store in the UK narrowly missing out on an A rating by only a few points and for this reason and the ones above I recommend this store for an award





The store	High RH fresh food cabinet
	

Beer cellar	Arctic circle free heat pack
	

Actual temperature profile	Standard cabinet