KEEPING IN THE COLD

INTRODUCTION

Cold store setup and management contribute significantly to the cost of operation. Cold stores are used within horticulture in a variety of situations and for different purposes, so a 'one type fits all' approach is rarely the most efficient. There are, however, several considerations to be made in ensuring that you get the best from your own or rented facilities. Some of these were explored during a two-day study tour in Denmark, by a group of hardy ornamental stock growers.

The five areas that can affect your cold store's efficiency are:

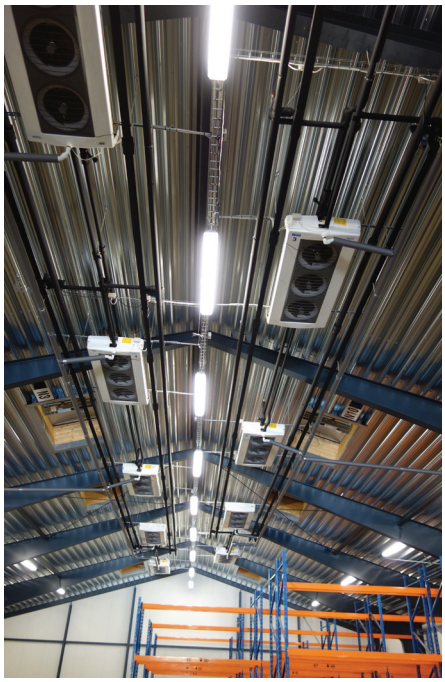
1. Control and management
2. Air movement
3. Air leakage
4. Insulation
5. Type of equipment

The order above reflects how easy or costly it is to address each: replacing equipment is the most costly and difficult, while control and store management can be relatively simple.

Most cold storage relies on refrigeration technology and, in particular, the use of fluorinated gas refrigerants (sometimes called F-Gases, CFCs or Freon) to turn electrical energy into cooling energy. The relationship between these is called the Coefficient of Performance (CoP), which is defined as the ratio of output power or energy to input power or energy. Generally, CoP values for cold store equipment in the UK should be around 3, i.e. a delivery of 3kWh cooling for each 1kWh of electricity used.

Efficiency of equipment can be compromised by the type of refrigerant, depleted refrigerant charge (caused by leaks in the system pipework), increased ambient air temperatures, dirty or iced up evaporators and condensers, and system settings.

One simple way to ensure your system runs efficiently is to make sure the air directed to cool the external condensers is as cold as possible. Roof-mounted condenser units were commonplace on the sites visited in Denmark and it was pleasing to see that most systems' condensers were clean. To ensure that the warm air exiting the condenser sets does not return to the inlet, maintenance staff retrofit units with low cost wooden baffles. Increasing the temperature of the inlet air by 10°C can see system performance reduce by 25% in worst cases.



With the legislation requiring an ever smaller refrigerant charge, there is a move, in both the UK and Denmark, towards Glycol filled units; an example of which was seen at a site run by Danplanex. These Glycol systems still require a refrigerant filled compressor, condenser and evaporator to generate the cooling, but these types of system have all the components closely mounted. This is advantageous because there is less refrigerant in the system, shorter pipework means there are fewer opportunities for leaks, there is less potential for components to be damaged, and maintenance costs are reduced. The evaporator is a plate heat exchanger, which transfers the cooling to a Glycol circuit, from where it is distributed to the stores at lower pressure. The evaporators in the store effectively become Glycol supplied fan coils; as the Glycol mix is significantly less cool than a refrigerant would be at this point, this type of store will need more fan coil units to deliver an equivalent quantity of cooling. Most stores seen had roof mounted cassette units. In similarly sized stores, those operating on Glycol had up to five times as many of these units.

One big advantage of using Glycol in the system is that heat can be recovered for use more easily. Danplanex were using the heat available to keep the offices warm, which reduces the electricity consumption of the refrigeration plant and also reduces the heating cost.

Another way of improving efficiency over a season is to use water to cool the refrigeration system rather than air. When cold stores operate during warmer spring and summer periods, the efficiency reduces as the ambient temperature rises. Water cooled refrigeration delivers 10°C cooling to the condenser unit year round. This was investigated in AHDB

Horticulture project ***CP57 - Pack-house cooling & crop storage: a commercial demonstration & economic evaluation of ground sink refrigeration***, which found that up to 20% improvement in efficiency was possible.

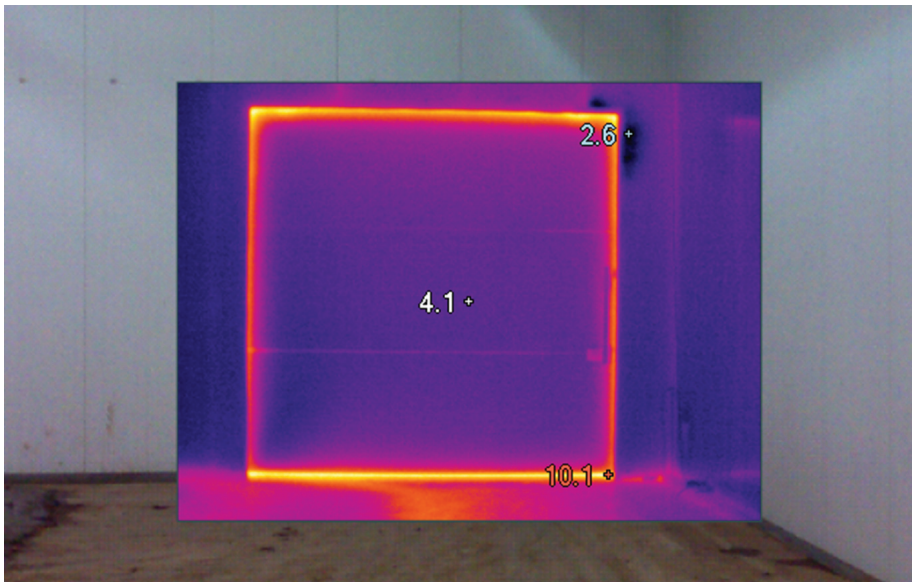
Using ambient cooling is another way of improving the efficiency of your store. Ambient cooling can be delivered when conditions outside are colder than required; typically a temperature difference of 2°C or more will be beneficial. Ambient cooling can be as simple as leaving a door open on a cold night, but it is better done with fan assistance and using louvres that can be closed when not needed.

Uncontrolled air exchange will contribute to increasing electricity costs for cold storage. Areas where air is leaking can be found by using a thermal camera, smoke testing or even by placing the back of your hand around suspect areas and feeling the air movement. Particular areas of attention are around main and personnel doors, louvres, where refrigeration equipment enters through the store wall, and between composite panels. Recent air leakage tests carried out in conjunction with AHDB Potatoes have shown that stores can exceed the building regulations' target air leakage rates for cold storage and, in some cases, even exceed the targets for general commercial buildings. Unnecessary air leakage can contribute up to 50% of store running cost during periods when crop is being held at a set temperature (i.e. after initial cooling has happened). Any store where produce is continually being taken in and out should be fitted with fast acting doors or, at the very least, strip curtains.

Thermal imaging can also be useful in determining whether insulation is effective and to look for problem areas. Particular attention should be paid to roof and wall joins and between panels, as these can often be missed when general purpose buildings are converted to stores. Minimum recommended U-values for cold stores are between 0.45 and 0.20 W/m^2/°C equivalent to 50 to 120mm of PIR composite panel.

Ensuring good air movement within the cold store and paying attention to how temperatures are controlled is generally the easiest way to ensure effective conditions at efficient energy consumption levels. An even temperature distribution will help produce to store for longer periods and keep quality high. Danplanex had an old store of a jacketed design, where cold air was ducted around the roof, walls and floor, ensuring very even temperature conditions and also meaning that product was not dried out unduly.

Setting up a cold store is critical to good cooling and it is important to make sure that cooled air is directed to where the cooling is needed, as determined by produce stacking arrangements. Problem areas should be identified through thermal imaging. If airflow is well managed, less air will be needed and produce will store better. Purpose fitted curtains to direct air to where it is needed and good trolley or box stacking will help this.



MANAGING AIR FLOW

The nature of moving air is to follow the path of least resistance, which is not necessarily the route intended by the store manager. The use of air divider curtains to help improve airflow in potato box stores is fairly common practice. Curtains can eliminate the short-circuiting of air around stacks, prevent air from 'leaking' through the sides of boxes, and force it to follow a desired path.

The stacking and position of boxes is also important. Many potato stores include additional stacks of boxes in front of the main stack. Although this maximises the storage space available, it can have detrimental effects on airflow. Consideration should be given to stacking arrangements and the trade-off between increased tonnage and reduced overall quality caused by poor airflow.

Overreliance on single temperature sensors to inform whole store conditions will give neither good nor even storage of product. Multiple sensors should be located inside the store at various positions and heights, with regular monitoring to ensure conditions are met. Wireless sensor technologies can be invaluable in getting sensor placement right, not just where it is easiest to install. However, it is important to consider that not all wireless sensors are of equal quality and the best sensors should be used, considering robustness, accuracy, sensor resolution and strength of wireless transmission. Wireless sensor interfaces are also variable and demonstration of technology is important before deciding to purchase.

Where it is not possible to install a fixed sensor (e.g. in the middle of a stack of boxes), portable loggers can be used. Additional measuring locations might include the corners of the store, as well as an array of locations across the crop, including at different heights. It is worth noting the monitoring locations, both for retrieval of the sensors and for identifying trends in measurements.

Another aspect of management leading to good efficiency is the loading of trolleys in such a manner that they can be removed from storage without needing to unload parts of the store to access them. Another site visited, Gartneriet Schroll, has designed its own boxes that can be stacked 12 high in cold stores and allow good air movement around the plants. This is similar in concept to bulk crop storage, where wooden boxes are predominant.

UNLOCKING THE POTENTIAL OF COLD STORES

During July 2016, a group of hardy nursery stock, bedding plant and pot plant growers visited a number of production nurseries in and around Odense, Denmark, as part of the AHDB/Dove Associates Denmark study tour. The remit was to examine how cold stores were being used to hold, manipulate and schedule crops. Businesses visited included: Danplanex Ltd, a cooperative tree and shrub wholesaler based at Rodekro, Nursery Leif Larsen, a producer of forced cut tulips at Middelfart, GASA group headquarters at Odense and Nursery Schroll, Arslev, a producer of pot plant hydrangeas. In the main, the stores were direct cooled (either purpose-built or converted), although a small number of jacketed cold stores were also visited. At Danplanex Ltd, the main use of the stores was to extend the availability of plant material over the season and to assist in the bulking up of larger orders. At Nursery Leif Larsen, the emphasis was very much on holding, scheduling and treating tulip bulbs, so that rooted bulbs in trays could be extracted sequentially and forced into flower throughout the production season. At GASA, the priority was holding plant material back, whilst at Nursery Schroll, four large direct cooled stores were used to hold and vernalise hydrangea plants for as long as six or seven months to provide a constant stream of plant material ready to be brought into flower, either under protection or on outdoor production beds.

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