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Energy Efficiency in Produce Storage

INTRODUCTION

This guide explains where energy used and can be saved in produce storage and cooling systems.

WHERE IS THE ENERGY USED?

Most energy used for storing and cooling crops is associated with moving air and refrigeration. Some energy may also go into washing, lighting, grading and packaging

WHERE CAN ENERGY BE SAVED?

Energy monitoring/management/benchmarking

Energy monitoring is a key factor in successfully managing energy use. It is a relatively cheap thing to undertake but without it, it is virtually impossible to make rational decisions about how to save energy and what techniques to use. In the majority of cases farmers rely on little more than their electricity bills to give them feedback on how much energy they are using. What's more, they rely on infrequent and often estimated readings. Good energy monitoring goes further and involves more regular meter reading and also measurement of individual system components. It allows you to:

- Identify high energy using equipment and times.
- Spot where problems might be occurring.
- Make rational investment decisions on energy-saving equipment.
- Compare other buildings, techniques or sites.

Energy monitoring can be anything from the regular and organised reading and recording of utility meters on site, to the installation of energy data logging equipment and the automatic interpretation of this data to take into account operational conditions and weather, with benchmarking against other sites or equipment and exception alarms to notify unusually high energy use.

Improving insulation

Clearly the greatest energy requirement for long term stores is for cooling and most of this is required to remove field heat and counteract high external temperatures. There are a variety of products on the market which will improve the thermal characteristics of stores. The wholesale re-insulation of stores is relatively costly and in some case the identification of particular problem areas and associated rectification can be more cost effective. There is a diverse range of insulation products and application techniques available to suit the building in question from composite boards to spray-on foams. There are also a number of novel products including low emissivity paints and reflective films which can be used to supplement conventional insulation.

Recommended insulation values (W/m^2oC)

Position of	Roof	Walls
Prevent frost damage	1.00*	1.00*
Reduced solar gain	0.45	0.50
Refrigeration minimum	0.3	0.35

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Common Insulation Materials

0.3W/m^2.^{o}C	= 60mm Urethane composite board = 75mm Spray on foam = 80mm Styrafoam board

Commercially, colds stores are often constructed to 0.3-0.35W/m2.oC overall.

Sealing buildings

Opinions from the supply industry and circumstantial evidence would seem to indicate that high air leakage is one of the primary causes of high energy costs in storage. The degree to which leakage is a problem is difficult to quantify on a site by site basis because it cannot be measured easily. But research carried out on similar types of buildings in other market areas would suggest that there is likely to be significant room for improvement on many sites. Simple building sealing is relative cheap and therefore very cost effective. Attention to key areas like joints in structures and doors is important. Exceptionally good sealing in buildings can lead to the build up of CO2 which can itself lead to problems with the crop and with safety. However, this is something that can be managed easily with controlled low level ventilation.

For pack houses and store which are heavily trafficked, strip plastic curtains or, better still, automatic doors should be used.

Fitting a better controller

Good control is an essential component in providing good crop conditions at the lowest energy cost. Compared with many capital investment options, control is generally quite cheap to integrate into an existing store.

Good control reduces waste by keeping temperature accurate and by utilising the cooling equipment to its best efficiency.

Facilities like remote diagnostics, multipoint temperature monitoring, and the ability to define refrigeration equipment operation to coincide with periods of cheap electricity availability all go towards reducing energy use and controlling costs. An example of this latter point from one manufacturer has demonstrated average energy use across a number of sites to be 57kWh/tonne. Without tariff control most stores average about 25% consumption during the cheap night tariff rate. With active tariff control night rate usage averages more than 50%. Savings at current tariff prices will be about 60p/tonne.

Variable speed drives on fans/pumps

Electric motors are generally single speed devices. The fall in price of power electronics now means that it is possible to apply a variable speed AC voltage to a motor and effectively operate it at any output speed. The main advantage of this is that the output of the device which the motor is connected to e.g. a pump, a fan or a conveyor, can be operated at optimum speed and energy input. This means that, what in the past has been regarded as a fixed parameter may be changed depending on crop requirement. A good example of this is with store ventilation where traditional ventilation rates are defined as fixed figures. By linking fan speed and output to exact requirements, large amounts of energy can be saved.

Generally, power consumption of many fans and pumps falls in proportion to the cube of the

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speed. Therefore small reductions in speed can deliver quite high energy savings.

High efficiency motors

Although the improvement in efficiency provided by new motor designs is small, the marginal extra cost of these devices is often justified when running times are extended. This becomes especially important when motors fail and their replacement or rewinding is being considered. In the case of rewinding motors, a small reduction in efficiency results from the rewind and affects the economic viability of this option compared with buying a new motor. Few users are aware of the economic consequences of rewinds/new motor purchase. Whether a high efficiency motor is viable or not depends on the additional purchase cost, efficiency differences and operational time of the application.

High efficiency lighting

Although lighting is not a massive cost to most producers, lighting equipment has a long service life and represents a steady background energy use. A new generation of lighting equipment using gas discharge tubes with electronic ballast will produce good-quality lighting at a fraction of the cost of lighting with tungsten filament based equipment. The economics are such that it is rarely worth installing a replacement lighting system on energy cost grounds alone. However, where old lighting has failed or where new lighting has to be installed for a new facility then the marginal cost of the high efficiency option is invariably worth it.

High efficiency fans and duct design

Fans are a large consumer of energy in cooling. It is often not appreciated that fans of the same energy rating can deliver significantly different outputs. The reasons for this lie in different impeller, motor and casing designs. Also inlet and outlet ducting configuration has a significant effect on efficiency.

Better refrigeration configuration

There are a number of newer techniques in refrigeration which can improve the coefficient of performance of the equipment providing more cooling for less power. Techniques include better defrost control, variable speed condenser fans, electronic expansion valves, variable speed compressors and alternative refrigerants.

This is a highly technical area and requires some detailed engineering evaluation in cooperation with manufacturers and installers of storage equipment.

Cheap period tariffs

Multi-rate and seasonal electricity tariffs, or a negotiated electricity contract, which offer cheaper rates at certain times of the day and/or year can be used to good advantage e.g. during the holding phase of long term storage when the cooling duty on refrigeration equipment is low. The major part of this phase is in the cooler part of the year and so any running time of refrigeration equipment can be restricted to times of the day when electricity is cheaper.

Better Lighting

A light level of not less than 60 lux is recommended for store loading, unloading and general crop inspection. Lighting levels of up to 400 lux are recommended for close crop inspection during grading.

High bay discharge lamps (HP Sodium or Mercury) are recommended for this purpose. These types of lights are about five times more efficient than tungsten halogen lamps.

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Heat recovery for water heating

Where hot water is need for washing (often the case with plastic vegetable boxes), a considerable amount of heat can be recovered from the refrigeration system condensers. A special water heater with a double skin that can carry the hot refrigerant gasses from the cooling system has to be used.

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