Insulating farm buildings

Insulation can result in efficiency gains of between 20 and 30 percent in some farm buildings, and is integral to the design of modern intensive animal production facilities. Insulation can be applied in roofs, walls and floors, and is best incorporated at the construction stage due to the cost and complexity of retrofitting. A wide range of products can be effective, potentially, in agricultural applications. Selecting materials and calculating your return on investment depends on assessing the specific requirements of your buildings and production system.

Why insulate farm buildings?

Any building that is heated or cooled by mechanical systems can benefit from some form of insulation. Insulating roofs is an effective way to save money on cooling during hotter months and can reduce heating costs when temperatures are cold. Adding insulation material to roof cavities, ceilings and other large surface areas keeps conditioned air (and desired heat/cool air) within the conditioned space.

Typically, intensive production facilities must maintain stable temperatures. Insulation can help to smooth out temperature extremes and in so doing, reduce the size, power and operating time of required heating, ventilation and cooling (HVAC) systems.

Often, you often save between 20 and 40 percent of the energy used to heat or cool traditional buildings through installing 'qualified' insulation material. Insulation is considered to be qualified when it complies with the performance requirements of AS/NZS 4859.1:2002 (Joint Technical Committee BD-058, 2002).

Where should insulation be used?

Insulation can provide energy and cost savings in farmhouses, poultry sheds, pork sheds, greenhouses, cold storage facilities and atmosphere-controlled rooms – basically anywhere that space heating or cooling is present. Roof insulation is generally the more cost-effective option and saves a greater amount of energy than does insulating walls or floors and is therefore recommended wherever it is applicable.

Understanding diminishing returns

Installing insulation yields diminishing returns. Every centimetre of thickness in the insulation you install saves you slightly less than the centimetre of insulation material below it. When insulating a structure, it is important to recognise this principle and to select the thickness (or rating) of material that gives the best return on investment.

Additionally, certain materials are more difficult to install than others. Some provide higher radiant-heat resistance per centimetre than others and some may have flammable or potentially toxic properties that the installer must be aware of.

Quick wins

- **Make a quick insulation audit.** Review the existing insulation in your main buildings. There may be some obvious omissions and opportunities.
- **Insulate roofs.** Roof insulation provides the most bang for your buck. Obtain and compare quotes for insulating the roofs of your main buildings.
- **Consider the entire HVAC solution.** The suppliers of elements of the system won't necessarily look at the full heating, cooling and ventilation picture. If significant investment is involved, consider obtaining expert advice from a party who is not a vendor.
- **Seal gaps and control doors and windows.** The efficiency of insulation and the effectiveness of your overall HVAC solution depends on the integrity of your building envelope.

Whether you install installation at the time of construction or via retrofit depends on consideration of several factors and may warrant obtaining independent professional advice. If you decide to do so, it is important that you hire a consultant who has detailed knowledge of the HVAC requirements of your specific production system.

Insulation requirements

Insulating material must comply with the performance requirements of AS/NZS 4859.1:2002, which outlines requirements for insulation material, performance and installation (Joint Technical Committee BD-058, 2002). When deciding on insulation materials, it is essential that you consider factors such as existing infrastructure, general moisture conditions, climate and cost.

Existing buildings

Retrofitting an existing building with insulation demands a different set of considerations than designing insulation for a new building or shed. When designing a new building, ensure designers and architects are aware of the proposed usage of the space, including the optimal temperature for crops or commodities that will be stored in the space; potential moisture issues from animal respiration; and other atmospheric considerations (such as humidity and fresh air).

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Generally, Australia recommends insulation to a total value of R-4.1 in ceilings, R-2.8 in walls and floors (Commonwealth of Australia, 2010). These values are for residential construction, but similar principles apply in all building construction.

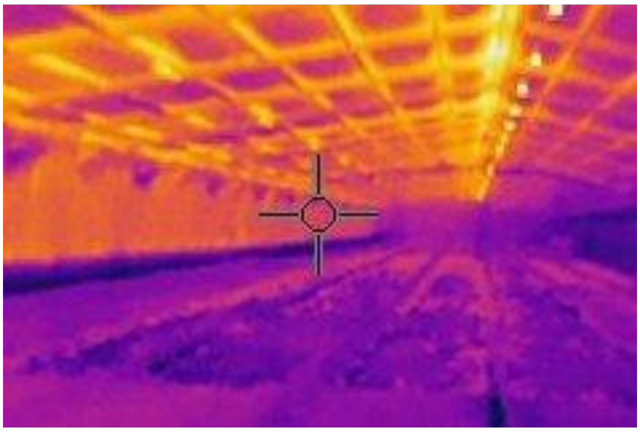
Location	Roof/ceiling	Wall
Bourke, NSW	4.1	2.8
Sydney, NSW	4.1	2.8
Katoomba, NSW	4.1	2.8

Table 1: Recommended residential R-Values in warm/mild temperatures and a warm humid climate, where reducing heat loss and heat gain are of equal importance. Notice that subtle climatic differences don't lead to a change in the recommendations (Commonwealth of Australia, 2010).

New buildings

In Australia, insulation guidelines dictate that new buildings are constructed with recommended levels of insulation. Insulation is not always installed properly, however, and poorly installed insulation will not perform effectively. If there are gaps or holes within insulation material, these should be filled and corrected.

When constructing a new building, additional thought should be put into the materials *to be* used. Usually, materials are selected for their permeability to water, structural properties and/or availability. Cost is also a major factor. When choosing building materials, consider performance over the life of the building, including the potential for some materials to act as an additional insulating layer. Also consider maintenance costs.



A thermal image shows leakage points (heat entry) in a farm facility. Heat entry can be seen as thermal bridging along the roof beams and through the side walls. Gaps or holes within insulation or in the general building envelope must be sealed to achieve the rated efficiency of your insulation solutions. These types of images are most effective when the temperature differential (deltaT) is greatest between the inside and outside of a building (Image: NSW Farmers 2013, using a FLIR i-7 thermal imaging camera).

Selecting insulation

There are many different types of insulation available. Specific manufacturers advocate the benefits of their products but every type of insulation has advantages and disadvantages.

Insulation generally comes in a few specific types: bulk insulation, spray foam and reflective insulation.

Bulk insulation

- **Insulation batts.** Like blankets, these materials can be laid out flat or secured to surfaces
  - Fibreglass
  - Rockwool: made from volcanic rock
  - Wool: sheep's wool
- **Insulation boards.** Composite boards, these are generally cut to size, secured on surfaces and sealed with foam or caulk around the edges.
  - Extruded polystyrene: more rigid, stronger
  - Expanded polystyrene
- **Insulation loose fill/dense pack materials.** Often made from the same material as batts, loose fill is usually a sawdust-like material that's pumped over or into spaces to provide insulation.
  - Rockwool loose
  - Wool loose
  - Cellulose
  - Fibreglass.

Spray foam insulation

Spray foam insulation is generally petroleum-based or soy-based wet foam material. The bulk material is mixed or heated and applied as a malleable foam-type product. Once applied to the desired surface, the foam either expands to fill enclosed wall/ceiling cavities or, sprayed on an open surface, dries in place to provide a radiant barrier.

Spray foams are either open-cell or closed-cell (low or high density), indicating their capacity to act as barriers to moisture and air.

Reflective insulation

Reflective foil-type insulation is another option for insulating roofs. However, this type of insulation works best in conjunction with other insulation materials (batts or boards), as it tends to lose R-value due to the accumulation of dust. Durability can also be an issue, and reflective insulation must be installed properly if it is to achieve the desired effects.

Technical explanation

Insulation works by increasing the thermal resistance between two spaces and making it more difficult for air and heat to travel between those two spaces. Air sealing with air and moisture barriers, in conjunction with proper insulation, will vastly increase insulation efficiency.

Insulation functionality is defined by the equation

$$R = \Delta T / \dot{Q}_A$$

where Q is a unit of temperature and A is a unit of area.

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This equation generally applies to one hour of time. So in Australia, the equation for determining the R-value of insulation is square-metre kelvins per watt ($m^2 \cdot K/W$ – or equally, $m^2 \cdot °C/W$). Manufacturers based in the US use a different formula for calculating R-values, so always ensure you have the proper R-value measurement. To convert from a US R-value to a standard global R-value, simply divide by 5.68.

R-values of material increase as thickness increases. Materials are generally differentiated by increments of 50 mm.

Poultry shed case study

Normally, chickens have a body temperature of 41 degrees Celsius. Birds regulate their temperature through energy in feed. Under normal conditions, birds produce excess heat which warms their surroundings and it requires ventilation to remove this heat. Birds that are too hot and cannot get rid of excess heat reduce their feed intake and resort to heavy breathing, which transfers air from the inside to the outside of their bodies. If birds are unable to rid themselves of enough excess heat, they will eventually die (Jess Campbell, 2006).

In hot weather, sun on the roof of poultry sheds will radiate into the shed and cause birds to heat up. The rate of radiation through an uninsulated roof (340–400 kJ/h on a hot day) can cause birds to overheat, forcing producers to install and run larger ventilation and air-conditioning systems for longer periods of time. Installing roof insulation – given that the roof is the major culprit in this heat-gain scenario – can reduce the amount of radiant heat in the shed. Installing five centimetres of extruded polystyrene insulation can reduce heat gain by approximately 90 percent and greatly reduce the building cooling load (Donald, n.d.).

Another option for insulating poultry sheds is incorporating dropped ceilings, covering these with batts or blown bulk insulation. Dropped ceilings also improve the efficiency of tunnel ventilation as they reduce the shed's total area and therefore reduce ventilation loads (Jess Campbell, 2006).

Incorporating a light/white roof to help reflect radiant heat is a further option should be considered, as it will offer additional cooling savings.

References

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