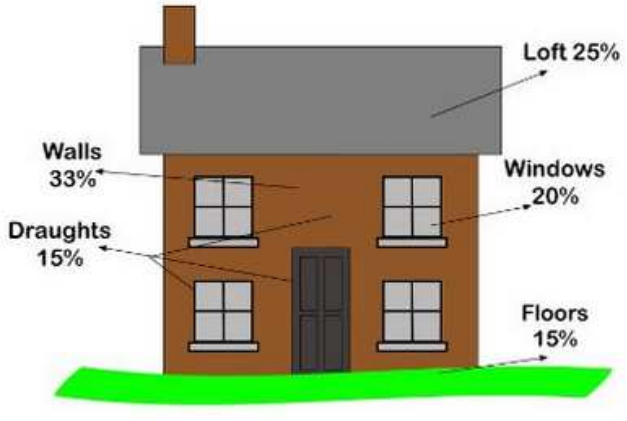
How do I choose the best insulation?
Investigating enhanced insulation for buildings



Heat loss diagram for a typical house (% figures rounded up)
© Eco-Home-Essentials

This diagram shows that much heat can be wasted from a house that is not well insulated. If all buildings were well insulated, heating costs would be reduced and energy consumption lowered.

Properties of some currently-used insulating materials

(a) open structure

Fibreglass: This is widely available, in rolls or as semi-rigid rectangles (batts). It has an open fibre structure, does not burn but melts at high temperature. The rolls produce fibres in the air so installers must wear masks and gloves. The rolls are not water resistant but the batts are. It has very good insulating value, is cheap and made by re-melting old glass bottles. It has a life span of a 100 years plus.

Fibreglass in the loft of a church
Peter Kennett

Mineral wool (rock wool): This is similar to fibreglass. It has a very high melting point so is used for high temperature insulation and fire protection and is a little more expensive than fibreglass. It is made from melting basalt rock or slag from iron smelting. Blown mineral wool is a good method of insulating old houses with cavity walls (called retro-insulating, since the building was not insulated during construction). It has a life span of 100 years plus.

Sheep's wool: This is available in bags and has to be placed and retained in position, It is easy to handle, has good insulating value, is non-toxic but burns fairly slowly producing unpleasant smoke. Water can flow into and rot the open structure, and it is vulnerable to pests such as moth and mice. Without rotting it has a life span of a few tens of years.

Horse hair: This has been used for insulation under the slates of slated roofs since the 1600s. In this context it is long lasting but not thick enough to be really effective. In the past, it was added into lime wall plaster and some of this can still be found in old buildings today.

Straw bales: Some new so-called 'eco' houses have been built with thick walls built from straw bales. Although such houses are cheap to build and are warm, straw rots when wet and may suffer spontaneous combustion (burning without warning). It also attracts insects and vermin. In mediaeval cottages, straw was sometimes used to insulate first floors which did not have a ceiling beneath them. The straw was overlaid with a mortar of lime and ash. Its life span is around 25 years.

Straw bale building,Centre for Alternative Technology Machynlleth, Wales
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Straw or reed thatch for roofs: This has been used for thousands of years. It is an effective insulator in the usual thickness of about 60cm, The outer layer lasts about 20 years and the whole has to be replaced after 40-60 years.

Cellulose materials such as newspaper and cardboard: These are readily available at minimal cost. The shredded bits are usually blown into position. They have a moderate insulating value and are rapidly destroyed by water. They are unsuitable for vertical insulation as they pack down under their own weight. They also burn easily. Their life span is around 20 years if dry.

(b) closed cellular structure
These materials have better insulating values than the materials in (a) but are derived from the petro-chemical industry and so have a bigger carbon footprint than other materials.

Polyethylene boards: These only meet flameproof regulations when an incombustible foil is added; this also adds reflective insulation. The material is thermo -plastic. i.e. it melts at low temperature and burns very easily producing black toxic smoke. Their life span is not established.
(In June 2017, a fire broke out in the 24-storey Grenfell Tower block of flats in North Kensington, West London. This insulation caught fire which rapidly spread through the building cavities to the rest of the building.)

Polystyrene boards: These are similar to polyethylene, less combustible but, once ignited, burn fiercely making very toxic smoke. At one time polystyrene was used as blown-in beads, but was difficult to retain in position and broke down to a toxic dust. They have a life span of around 30 years.

Both of the above have been replaced generally by the following:

Polyisocyanurate boards: These usually have foil on both sides. They have very high insulating value especially with the reflective properties of the foil. They are thermo-setting, i.e. they do not melt. They do not burn well but they char, producing toxic smoke. They are completely waterproof. They are available as a bonded back to plasterboard, so are useful in the improvement of old properties with solid walls.

As they can be cut to precise dimensions, they are used in factory-made, pre-insulated timber-frame houses. Although the initial ingredients are petro-chemicals, the manufacturing process is a low-energy one. Their life span is not yet established.

left - Polyisocyanurate board
above - charred board

Elizabeth Devon

Ask the pupils
The motion for a classroom debate is *"The best and most effective insulation for buildings is Polyisocyanurate boards even though they are made from by-products of the petro-chemical industry".*

Ask the pupils, in small groups, to consider their arguments for and against the motion for that debate. They must be able to give reasons both for and against the motion.

They should consider the following points:
- sheep's wool, straw, horsehair, etc. are often considered 'new' but they have been used since the Bronze Age;
- fibreglass and mineral wool are fireproof, use very cheap and often waste materials but are energy-intensive to produce;
- polyethylene and polystyrene boards are a fire hazard;
- polyisocyanurate boards are easy to use and effective but use expensive petro-chemicals;
- newspaper etc. is very cheap but limited in use and effectiveness, and has a short life;
- if a house is so sealed that no air can get in from the outside, CO_2 levels inside rise and O_2 levels fall. The building regulations require ventilation of 1-3 air changes per hour, depending on use. Occupants also produce water vapour. If this vapour contacts a cold surface such as a single glazed window, condensation takes place. If vapour is not prevented from entering open structure materials, condensation may take place within the insulation with damaging results;
- there is no current insulation which meets all criteria in all circumstances so choices have to be made.

Back up:
Title: How do I choose the best insulation?

Subtitle: Investigating enhanced insulation for buildings

Topic: An investigation into the properties of various insulation materials for buildings with a discussion on their advantages and disadvantages

Age range of pupils: 14 years upwards

Time needed to complete activity: 30 - 60 minutes depending on the levels of discussion

Pupil learning outcomes: Pupils can:
- describe a variety of insulation materials;
- explain the advantages and disadvantages of each type;
- realise that a compromise about which to use must always be made;
- realise that ventilation in a well-insulated building is very important;
- realise that some consideration must be given to what happens to the water vapour in well-insulated buildings.

Context:
To reduce energy consumption, it is important that buildings should be well insulated. There are many types of insulation available but all have both advantages and disadvantages. This activity aims to give pupils an overall view of insulation materials currently available and sufficient information for them to make informed choices.

Following up the activity:
Investigate other ways to cut down energy consumption in buildings for example: smart glass, double and triple glazing, draught sealing, orientating buildings to catch most of the sun with main rooms on the south side and few and small windows on the north side.

Search 'net-zero' on the Earthlearningidea website to find other Earthlearningideas relating to climate change mitigation or adaptation. Use a search engine like Google to explore the internet for more information about likely global impacts of 'net-zero'.

Underlying principles:
- There are two types of insulation material, open structure and closed cellular structure.
- Factors such as cost, fire resistance and life span vary according to the type of insulation.
- Raw materials used for insulation vary according to type.
- Adequate ventilation must be provided in well-insulated buildings.

Thinking skill development:
A pattern develops as the various types of insulation material are described. Discussion about which is best to use in certain circumstances involves metacognition and cognitive conflict will occur when it is realised that materials derived from the petro-chemical industry are amongst the most effective. Applying the findings from this activity to choosing insulation for a property is a bridging skill.

Resource list:
- internet and reference books

Useful links:
Eco-Home-Essentials
https://www.eco-home-essentials.co.uk/best-insulation-for-homes.html

Source: Martin and Elizabeth Devon of The Earthlearningidea Team