Low energy museum and in Denmark – and worldwide

Talk at the CRCC conference, Paris , 23 – 25 oct. 2013

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Ladies and gentlemen, good morning. The purpose of this presentation is to demonstrate that saving energy is not incompatible with preservation of our collections. You can safely cut most of the energy cost without risk of losing your head.

First we must accept that a museum store is not for people to work or stay in. Therefore, the temperature can be lower than what is needed for humans. Proper clothing is important for the comfort of the museum staff

Low temperature is a benefit, both for the conservation of objects and energy. Low temperature will retard most chemical reactions, whereas high temperature will accelerate the decomposition of most organic and synthetic materials.

Hydrolysis is a main agent of decay, controlled both by temperature and relative humidity. We will define a the decay rate of 1 at 20 °C and 50 %RH

Any combination of T and RH with the same decay rate defines a line of equal decay rate

An increase in T by 5 degrees will double the decay rate. A reduction in T by 5 degrees will slow down decay to only half the speed.

At 0 °C decay is 20 times slower than at 20 °C. This indicates the importance of temperature. Relative humidity is less significant.

Hydrolysis is particularly important for paper collections. Here is a store for the the Royal Library in Copenhagen.

This building has full air conditioning, which is expensive to install, run and maintain

The advantage of HVAC is this. It is possible to meet very tight climate specifications for both temperature and relative humidity. The cost is 28 kWh/ m3 . The decay rate is around 1,2

A museum store can work without heating, but with dehumidification as the only climate control. The absorption dehumidifier is a simple and robust technology. It works well at low temperatures.

When there is no heating, the annual temperature will follow that outside. The RH is controlled within tight limits by the dehumidifier. The chemical decay is slower due to the lower average temperature about 0,5 over the yearly cycle. The energy consumption is 6 kWh/m3 per year. We get a double lifetime with an energy use of less than 25 %.

The temperature variation can be reduced by the thermal inertia of the building. But even very heavy structures cannot deal with annual variations. The roof of this building is ½ meter thick solid concrete. It was designed as a nuclear safe shelter for fighter airplanes, but is now used as a temporary store for a collection of furniture.

Here is the climate record of this building over 5 years. The RH is quite constant thanks to the dehumidifier. Notice the steep fall as it is turned on. The annual temperature variation is from 0 °C to 25 °C . This is perhaps way out of your comfort zone but the furniture doesn’t mind.

This museum store in Ribe performs much better. The walls and ceiling have good thermal insulation, but the floor is not insulated. The store has dehumidification but no heating.

The winter and summer extremes are reduced by the right combination of thermal insulation and heat capacity. The temperature is 8 – 16 degrees and the RH is 40 – 60 %. The decay rate is 0,4 or 3 times less than the Royal Library. The energy use is only 1,5 kWh/m3

The climate record for one year shows the gentle annual variation in temperature and relative humidity. There is no daily variation.

The concept for a low energy store is very simple. Well insulated walls and ceilings and a floor without insulation to absorb heat in summer and release heat in winter. Relative humidity is controlled with a dehumidifier. The natural infiltration rate should be 0,05 h-1 or less.

Heat gain from the floor keeps a moderate temperature in winter. Dehumidification is not needed. Humidity control is mainly by buffering with wall lining or by the stored objects

The power needed to run dehumidification can be supplied by photovoltaic elements on the roof. Since dehumidification is only needed in summer, there is

plenty of sunshine to generate the electricity. This concept is energy neutral and needs no external power supply, apart from the sun.

Solar heating can replace humidification. The attic is used as a solar collector to allow exactly the heat gain needed for humidity control in summer. This design is entirely passive and free of maintenance. It will work for 1000 years without human involvement.

These concepts all rely on heat storage in the ground below the building. This diagram shows the temperature gradients in the ground. To the left is the winter situation with an inside temperature of 7 degrees Celsius in February. To the right is the summer situation with 15 degrees indoor in August. The floor acts as a heating element in winter and as a cooling element in summer.

It will work in most inhabited places on earth, but with different ranges for the temperature. Dry climate zones may have too low RH, so humidification is required. Computer modelling will predict the performance in any location. We tested the climate in Canberra for a recent project.

The temperature variation is 12 – 18 degrees. The RH is 50 – 75 %, so dehumidification is needed in some periods.

Please feel free to use the concept for your next project. We are always prepared to help in case you need it. Please read more about it at this website. Thank You for your attention.