European Science and Technology in Action:
Building Links with Industry, Schools and Home

Designing a Low Energy Home

The project we want to develop in this Learning Unit deals with the idea of a model house that uses less energy to heat the rooms and makes use of scientific discoveries and technological resources to minimize energy consumption. The house analysis will be the starting point to explore some important scientific concepts related to heating and cooling of bodies and to heat transfer.

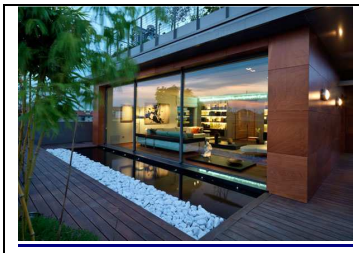
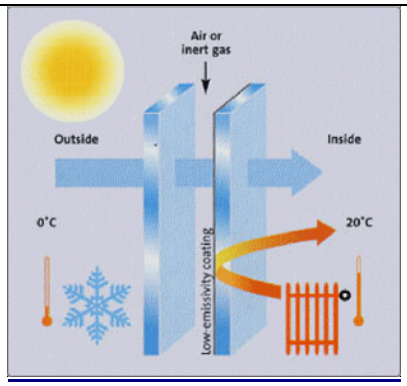
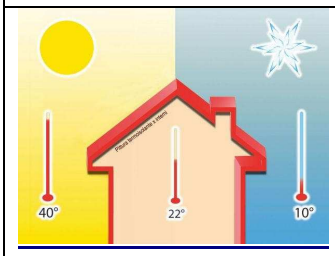
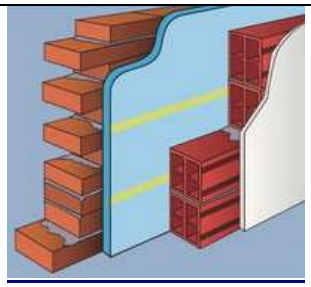
Even if we will work with models of polystyrene, wood, plastic and cardboard, warmed by a light bulb placed inside, we will apply the same principles of science and engineering that are taken into account in the construction of a real house.

In many countries a large percentage of energy consumption is due to heating and cooling of buildings. Therefore, the search for more efficient methods of construction to improve the energy efficiency of buildings is extremely important. Less energy means less fossil fuels and thus a lower amount of carbon dioxide in the atmosphere. Your generation has the task of doing something about energy efficiency and then you need to know the problem to make responsible choices.

Some initial considerations

We begin our work by observing the characteristics of some houses. Then, we try to understand why they are very different from each other.

		The houses in mountainous areas are often made of wood or have very thick walls
		The Mediterranean countries and the souks of the desert have whitewashed houses and narrow streets

		The houses with large windows often use double (or even triple) glass window panes separated by an air or other gas filled space to reduce heat transfer across a part of the building envelope.
		Companies that sell thermal insulation material for walls show as layers of different materials can be more successful at maintaining a constant temperature inside a room than walls made of only a material
		Photocameras are available that can show and highlight the different temperature of various parts of the outer wall of a house (thermocameras).

Although our goal is to build a model home that is efficient from an energy point of view, that has a constant temperature and can also be heated by the sun, we will start working with models to familiarize with the materials, construction methods, and measures necessary to evaluate the project.

Your teacher will provide you with the models on which we will use standard procedures for measuring the thermal performance of a house.

In order to cool a house (or as it is commonly said losing heat), there must be a difference in temperature between the inside and the outside. The inside of the house must be warmer than the outside. Because you cannot cool your classroom at 0 ° C, we will try to heat your model house at 15 ° C above the environment temperature. This is done with a heating bulb placed inside the model.

As in a real home, what matters is how long the heater must stay switched on to keep the house warm. The higher the inner temperature, the more energy is used and the more you heating bill will be. To mimic this situation, we will record the percentage of time the heating lamp should stay turned on to maintain the house at 15 ° above ambient temperature. We will perform the same test in other conditions, trying to understand why different results are obtained.

Activity 1_1: How to maintain warm your house model

The problem:

In the winter we need energy to maintain warm our house. By using suitable designed house models it is possible to analyze how much energy it takes to have the inner part of each house model 15°C warmer than the air outside it.

Material needed for each group:

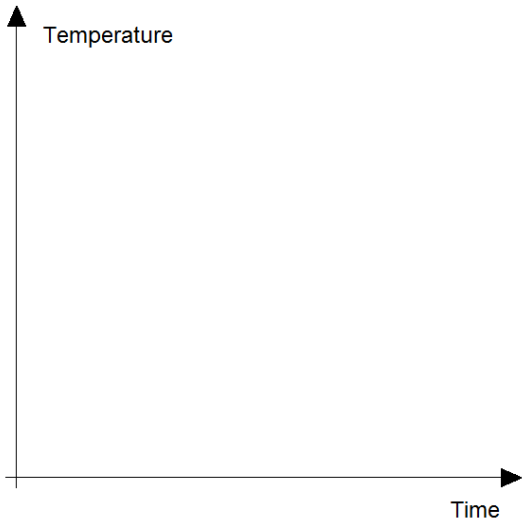
- Boxes of different materials (of equal dimensions) modeling different kinds of houses.
- Temperature sensors to put in the wall opposite to the heater.
- Heaters (light bulbs covered by aluminium sheets)

Suggestions for use:

Follow the suggestions of the teacher and place the heater and the thermometer as shown in figure.

In this experiment you will switch on the heater and start recording the inner temperature of the model house as a function of time.

Before actually performing the experiment, give your prediction of the Temperature-Time graph you are going to obtain and draw it on the right.



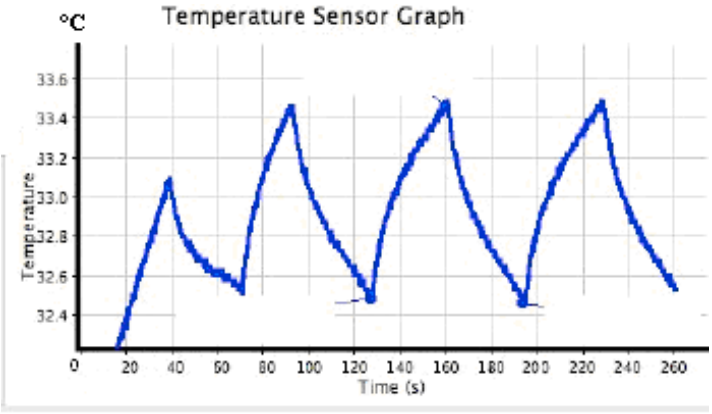
Now turn on the heater and record the inner temperature of the model house until it reaches a value of about +15 ° C above the external temperature, T_e. Turn off the heater so that the temperature decreases until T_e.

DATA ANALYSIS

Take note of the time intervals during which the heater is turned on and off and say how much energy was used to heat the house?

Compare your data with those of your schoolmates. What conclusions can you draw with regard to energy saving?

In depth analysis:



The graph above shows an experiment performed by a student that repeatedly switched on and off the heater, aiming at maintaining the temperature of the house at about 33 ° C. Try to calculate how much energy has been used if the heater was a 40W light bulb.

Activity 1_2: How is the temperature distributed inside your house model ?

The problem:

It is easy to observe that inside a heated room different places are not at the same temperature. How can we identify places at higher temperatures? Think about the model house you used in the previous activity.

Use two temperature sensors and design an experiment to test your hypothesis. Discuss your ideas with your classmates and the teacher

A group of students has suggested that the temperature in the upper part of the house will be higher than the bottom because "*heat always goes up*".
What does it mean in your opinion the expression "*heat always goes up*"?

Design an experiment that can be used to investigate your classmate hypothesis, and describe accurately the various stages of the design.

After discussing your project with the teacher, carry out the experiment and report below the most significant data.

An heat pump is a machine able to transfer thermal energy from a body at a lower temperature to a body at a higher temperature or vice versa, using different forms of energy, usually electrical. What problems can be incurred if the pump is placed on the wall as shown in Figure?

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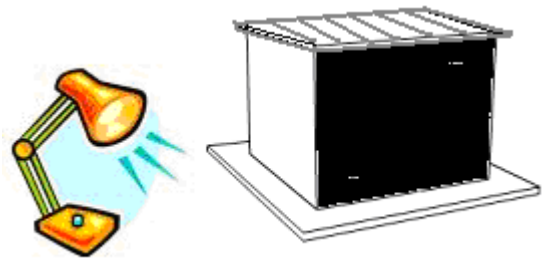
Activity 1_3: What is the effect of sunlight on the temperature inside your house model?

Surely you have heard that being exposed to sunlight by wearing a dark shirt makes you feel warmer than if you wear a white shirt. Is, in your opinion, this only a rumor or the statement has scientific basis?

How could you verify this?

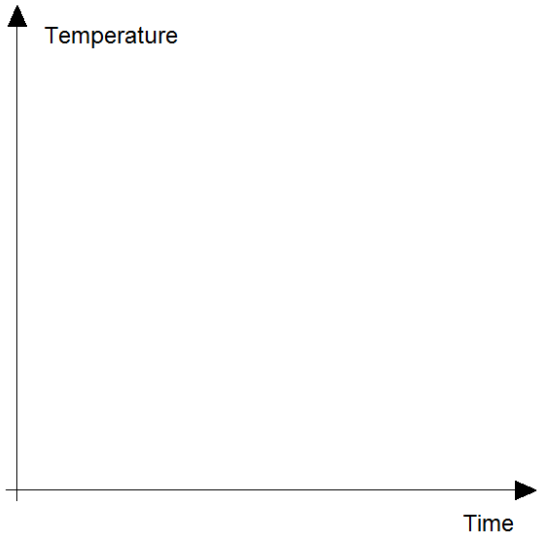
The problem we want to study now is how sunlight can affect the internal temperature of our model house. To do this we will simulate solar illumination with a high power lamp.



Consider the model house that the teacher shows you. Design an experiment to test whether the color of the illuminated wall affects the internal temperature of the house.

Describe in detail your experimental project

Draw in the graph below which type of Temperature-Time relationship you'd expect



After running the experiment, compare the graphs obtained with the predicted ones. Are there similarities or discordances? Explain your results

Conclusions:

Try to summarize, for each of the activities you have performed, what you learned at the end of each activity and how you came to the different conclusions you have drawn.