Solar Heating - – water and buildings

Go to the solar water heating display in the middle of the site, near wind and water power.

Inside the display there is a sink on the right and a large tank to the right of it. This tank is only heated from the three panels above it on the roof (to the right of the roof). The smaller tank at the front has been cut open to show how the hot water from the panel passes through the tank in a copper pipe.
How hot is the water from the tap in the sink? You might need to run the tap for a bit to get rid of the cold water in the pipe.

The temperature is affected by a number of factors:

what time of day is it?

what time of year is it?

how sunny has it been today?

how sunny was it yesterday?

how many visitors do you think have come round today and used some of the hot water?

Given all these factors is the water hotter or colder than you'd expect?

(When it is quite sunny the water heated by the sun has to be mixed with some cold water so that it does not burn visitors' fingers).
The system has a pump – why?

What do the electronic controls do?

Outside, the panel with the kettle has a thermometer attached. What is the temperature?

To the left of that panel there are four small panels with thermometers above (under flaps that lift up). What are the temperatures?

Metal (white) metal (black) insulated behind glazed & insulated

On average in Britain people could get half their hot water from solar energy over the course of a year (not for central heating but showers, washing up and all the other uses of hot water). What do you think this pattern of solar heated water production would be like over the year?

Materials used in the solar water heating systems

Why have the following materials been used in this display –

Copper pipe inside the tank

Foam on the outside of the tank

Metal panel inside the panel with the kettle attached

Glass on the front of the panel

Rockwool in the panel made from an old radiator

Is there a suitable place on your home to put solar water heating panels? If so, where and why?

Passive solar heating of buildings

Passive solar heating means designing buildings so that solar energy can get in easily to heat up the space inside. Ideally it also means trying to store the heat for as long as possible.
It is necessary to make sure that the building will not overheat.
Look at the Self-build house and describe how it uses passive solar energy (and loses excess heat).

Look at the shop and describe how it uses passive solar energy (and loses excess heat).

The earth walls hold the building up but they also have a useful function on the passive solar heating system. How?

What makes passive solar buildings pleasant to be in?

Solar Electricity

Solar cells – Photovoltaics - PVs

Go to the solar electricity display.
Solar cells are called photovoltaic cells (PVs for short).
What do they actually do?

PVs are made of silicon ‘doped’ with such impurities as phosphorus, boron or arsenic to make a semiconductor. There are two layers, each doped with different impurities.
When enough light falls on them a current flows. One cell produces a voltage of 0.45V.
The current varies according to the light level.

Look at the Solar powered pump. It has 5 panels of cells (each circle is a cell). What voltage do you think each panel is designed to produce? (there is an extra margin to guarantee they produce what is required)

Do you think the panels are linked in series or in parallel?

In maximum sunlight each cell will produce a watt of power. How much will each panel produce?

When will they produce their maximum output?

Is it pumping water at the moment?

Would you expect it to be, given the weather, time of day and time of year?

If the pump is working, put the clouds over the panels. Try to get the pump to slow to the point where it actually stops briefly.
What is the function of the capacitors?

Which direction are all these solar cells facing?

Why do they face this way?

Why are they set at the angle they are?

Look up at the roofs of the buildings around you. One of them is covered with solar cells. These solar cells should produce a maximum of 13.5kW of electricity.
Sometimes they will produce less than this and sometimes they will produce nothing.
Draw an estimated graph of the average power output from this roof.

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Behind the restaurant there is a control room with a large window. Inside there you will see a computer screen which gives all sorts of information about the solar roof. At the bottom of the screen in the middle there is a little box labelled “overall output power (kW)”. What is it producing right now?

In practice, the output of this roof is less than we hoped. The whole array of cells generates power at 200V dc. It then goes to a convertor where it is increased to 800V. It is then either fed to the mains (converted to 240V ac first) or is changed to 48V and fed into batteries.
Where do you think it is losing energy?

How much did this roof cost?

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Look at the display panels with information about solar electricity. Look for the picture of a house in Oxford which has solar cells on its roof.

How much did those solar cells cost?

That house in Oxford also uses solar energy in other ways. What other ways?

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Solar cells have no moving parts so should need no maintenance. Give two examples of the sort of situation where this makes them a suitable source of power for a very practical use.

Wind Power

An electricity generating windmill is properly called a wind turbine or aerogenerator.
Near the restaurant there are steps which lead up the bank to a platform where you can see a 600kW wind turbine. This belongs to the Centre but the electricity goes into the grid. In a very windy position a wind turbine that size would produce enough electricity for 500 homes.

Now go to the wind power display where there are a variety of different machines of different sizes and for different functions. Notice the numbers of blades and the different shapes and sizes of blades.

From the middle of the wind power display you can see the wind turbine up on the hill which produces a lot of the Centre's electricity. This is a 15kW turbine, called a Polenko. Is it turning?

Look at the top of a 250kW windmill (the nacelle) which has been cut open to show the parts inside and labelled. With the help of this and the signs in the display, draw and label diagram which shows you how a windmill to generate electricity works.

Why does it have a gearbox?

Is the windseat working today? This is an old wind pump.

Compare the blades with the ones which generate electricity. Describe the differences.

To generate electricity the rotor needs to turn fast. To do mechanical work (to move something heavy) they need a strong turning force (torque). How do you think the numbers and shape of the blades relates to this?

How would you describe the wind today?

If it's blowing at all, which direction is it coming from?

Down in this display is not a good place to put windmills to produce useful power. Why not?

Could we get much of our electricity from windpower in Britain?

What sort of places could we put them? Where will the strongest winds be?

Is it fairly cheap or expensive to make electricity with the wind?

After about 25 years a big windmill will be worn out and will have to be taken down. What do you think would be left on the site after it has gone?

How much more energy do we get out of them in their lifetime, compared with the energy used to build them and look after them?

The only significant impact of windmills is that we see them. We need to put them in places where t wind speed is strong enough, often enough to produce a lot of power. What sort of locations would this be?

How could windpower fit into an energy strategy for Britain?

What do you feel about windmills? Would you like to see more of them in Britain? Why?

Buildings and materials

Places around the site to find information – the Whole Home, the Shop/Information Centre, self-buil house, all the buildings

Some of the buildings on this site were built over a hundred and fifty years ago and were refurbished 25 years ago when CAT opened. Other buildings have been added over the years.
Various different materials have been used in the buildings.
Here when we choose materials to build with we think about a number of things:

- They should be produced as locally as possible so that minimal energy is used to transport them
- They should use as little energy as possible to make (embodied energy)
- They should not damage anyone's health (builders or users)
- They should be renewable (not using up a finite resource)
- They should be visually attractive

Ideas about what materials we should use have changed over the last 25 years with improved information.
Why do you think we have used the following materials?

Wool

Straw

Wood

Earth

Slate

Some materials are used as insulation. What are they?

Some materials are used to store heat. Which are they?

Explain the difference between materials which insulate and ones which store heat.

Why do you think we no longer use (or use as little as possible) the following materials?

Fibreglass insulation

Styrofoam insulation

Cement and concrete blocks

PVC (poly vinyl chloride)

Two of the buildings on the site have been designed so that solar energy can come in through windows to heat the building up (this is called passive solar heating).
Which buildings are they?

Draw a sketch of one of them to show how it does this.

Building houses so that they use passive solar energy does not cost more. Why do you think so few new houses are designed to use solar energy in this way?

What rules would you set for all people to follow when they are designing new buildings in Britain?

ENERGY CONSERVATION

Go to the building with the Shop and Information Centre. This building has been designed to be energy efficient in many ways.
What type of windows are they and why have they been used?

In the Information Centre you will find a little “window” which lets you see inside the wall.
What is the wall filled with?

Why?

Why do you think this particular material has been used at CAT?

Why have we not used any cement in this building?

In the **SELF-BUILD DISPLAY**, next to the wind/sun phone box you will see a different type of insulation displayed. What is it made from?

Now go into **THE WHOLE HOME** display inside the house nearby.
There is a great deal of information here about saving energy in direct and indirect ways.

Explain how you could insulate your home (using drawings if you want to).

Where might you find draughts in your house?

How can you save electricity at home?

What electrical gadgets do we use which are not really necessary?

How can you save energy when you are cooking?

What other ways can you save energy in the kitchen?

How could you save energy in your school?

How could you save energy in transport? How could you reduce your family's use of the car?

What action could government and councils take to make it easier for most people to live without the car?

What about reducing the impact of flying off on lots of foreign holidays? How can we do that?

One of the most significant ways that we use more energy than is necessary is in the food we eat. Growing food does not use huge amounts of energy but processing, storing, packaging and transporting uses an enormous amount. How could we reduce this?

ORGANIC GROWING

Go to the polytunnel and then through the **MOLE-HOLE** (slowly enough to really appreciate it) to the start of the garden.
The problems gardeners have to deal with are dealing with the weeds and pests which eat the plants and feeding the soil.

What micro-organisms do you see displayed in the molehole and at what magnification?

What useful jobs do these creatures do?

What happens to these creatures when pesticides are used?

What do the words ‘organic growing’ mean to you?

Give an example of a food chain, starting with a plant and ending with a mammal.

Have a look at the **PEST CONTROL** display.
What predators are useful to a gardener? (not just the ones we show here)

Have a look at the **COMPOST BINS** in the display. Choose one and make notes and sketches so that you could make one at home or school.

All the things in the compost bins will rot. Lots of different organic material is being made into compost. Make a list of at least *six* different types of things you can recycle into compost.

When people do not have compost bins what happens to these things? Where do they end up?

What are the advantages of putting all this organic material into compost heaps?

We compost the sewage but we keep it separate from the other compost and we never put it on the lettuces. Why do you think that is?

What usually happens to sewage in Britain? Where does it end up?

On these few acres at CAT there is a huge variety of species of insects, birds, small mammals and plants. Why do you think there is so much biodiversity here?

What are the dangers for the future if we carry on chemical farming?

What would the advantages be in growing some food organically in your back garden?

In The Whole Home display “Garden flows” shows how a garden could be used for different functions. What different uses can you see?

How could you redesign your garden to produce food, encourage wildlife and be a pleasant place to relax?

Renewable Energy in School

Most of this worksheet asks you to look at and consider things at CAT but in order to complete it yo will need some information from school. You can get the school information either before or after yo visit.

Consider what types of renewable energy you could use in your school.
You need to consider what the renewable energy could do.
Could it provide useful energy to do a real job (replacing some fossil fuel energy) or will it be used to demonstrate something?

You will need some data on the electricity, heating and hot water consumption of the school in order to make a decision on whether renewable energy could make a significant impact to reduce the school's use of fossil fuels. You will need to know, not just what the total consumed in the year is, but when it is consumed. What is the pattern of consumption?

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There has to be enough potential energy available in order to use renewable sources of energy efficiently.
Water power requires

Wind power requires

Solar power requires

Biofuels require (biofuels are plant or animal material used as a source of energy. So wood is a biofuel):

Look at the amount of water which flows through the Pelton wheel turbine here. Calculate how much water that is per hour. What is the head? (How far has the water fallen?)

Would hydro electricity be an option for your school? Why/why not?

Look around at the wind generators in the wind display. Observe the speed at which they are turning and whether they are running smoothly. Then observe the small windmills high up on the slate tip (this is in fact rather too turbulent to be a very good site) and the Polenko up on the hill above CAT (look at the display to see which one it is).
Do you think that windpower might be an option for your school? Why/why not?

If it would be, where might you put a windmill?

Is there a convenient place to put a large solar system on your school? If so, where?

Look at the large solar electric roof at CAT. This is a 13kW system so in very bright sunlight it should produce about 13kW of electricity. . If you look at what a solar electric system produces over the course of the year, in Britain, it is about 10% of what it would, if it was producing its maximum constantly.
How much electricity could this roof be expected to produce over the course of a year?

The solar cells added £75,000 to the cost of the roof. They would be expected to last for at least 20 years. What would the electricity cost per unit? (a unit is a kWh)

How much area of solar cell would you need to produce a reasonable proportion of the School's electricity? (think about when the cells would produce most power and when the school uses most)

What would this cost?

Look at the solar water heating display.
40,000 houses in Britain have solar water heating systems. The system collects solar energy during the day and produces a tankful of hot water. Most homes use hot water in the evening and morning.

What is hot water used for in the school?

When is it used? What time of day and what months of the year?

How much is used?

What does it cost? (You will need to find this out in school)

Does your school have a swimming pool?

Does it have heated water, how is it heated and what does that cost?

How could biofuels be used in the school?

Burning wood can be efficient if there is a source of timber fairly near the school. How would the timber have to be managed in order to make this sustainable?

Why does the woodland need to be fairly near to the school?

Solar energy can also be used to heat buildings in what is called “passive” solar design. This involves putting a lot of windows on the south facing side of a building to allow solar energy in to heat the building. Then there are various things to consider:

How can the heat be stored overnight?

How do you prevent it getting too hot?

What are the functions of the rooms? Where do you want direct sunlight? Where do you want daylight but not direct sunlight?

Go and look at the conservatory on the Self-build house and the shop and see how they use passive solar heating. Look at the way the shop uses passive solar energy without having direct light in the working areas, but is well lit by daylight.

What potential might there be to use passive solar energy in your school?

Saving energy is much cheaper than generating it and it normally has no negative impact on the environment, but a lot of benefit.

Look around your school and try to evaluate:

how efficient it is at saving energy,

whether any energy is wasted

what you could do to reduce the energy use in the school.

What about energy used to bring pupils and teachers to school?

How could you reduce the use of the private car for school runs?

In what ways could a demonstration renewable energy system be valuably used in your school?