MONITORING SCHOOL ENERGY CONSUMPTION

Goal(s):

The mains goal of the energy monitoring activity are:

- To make the pupils and all school staff aware of school energy consumption; and
- To show how changes in season and types of school activity influence the level of consumption.

The idea is that the results of the monitoring and increased understanding of energy issues, creates a basis for changing the behaviour of people in school so that energy consumption is reduced. It is also hoped that the pupils will take this knowledge home and encourage their families to reduce energy consumption (through the power of 'pester'!)

See other inspirational activity sheets in this tool-kit to help increase energy awareness amongst your children. Ultimately we need to use energy more efficiently to help combat global warming and secure the planet eco-system.

General description of the activity:

For an entire school year the pupils record:

- weekly energy consumption,
- average weekly outdoor temperature,
- significant school activities during each week which might alter energy consumption up or down e.g. a class might be absent on a field trip, or the school might be used out of hours by a community group.

A shorter time span is possible. However, the energy consumption may vary significantly during a year. The longer the duration of the energy monitoring, the greater the reliability and usefulness of the data collected. We therefore recommend that the monitoring be carried out for at least 12 weeks. The monitoring period should preferably include 3-6 weeks from each of the four seasons.

We strongly recommend that your pupils record their data on the website http://sustain.no where a large number of schools from all over Europe have also entered their project data.

Don't panic! There are 5 appendices called 'Aids' below to help you through the monitoring and recording processes and your friendly local energy agency can also help.

Basic information on various energy sources:

In schools and at home energy is used for space heating and cooling, hot and cold water, lighting and electric appliances.

Energy is delivered to the school by an energy supplier. Energy can be produced by

- fossil fuels, (oil, coal, natural gas, and petroleum);
- waste;
- uranium (nuclear power); or
- renewable energy resources.

Fossil fuels contribute to carbon dioxide (CO_2) as well as sulphur and nitrogen compounds emissions, renewable energy resources do not.

Waste is used in some countries as fuel in district heat and power plants or for production of propane (a type of gas that can be burned like natural gas). Using waste as an energy resource avoids the need to use land-fill sites which can pollute water sources, can smell and are unsightly.

Uranium is another important source of energy. While it does not contribute to pollution in general, due to radio-activity, it constitutes a safety risk that is considered unacceptable to some countries.

Renewable energy resources are types of resources that are remade by nature in a relatively short time. They include:

- hydropower (rivers/dams)
- wind energy,
- solar energy (sun)
- biomass (plant products)
- geothermal energy (underground heat)
- ocean power (waves)

Hydropower is produced by turbines which are turned by strongly flowing water of a river. Sometimes this strength of flow is produced by the creation of a dam across a valley.

Wind energy is produced by wind-turbines ('windmills').

Solar Energy uses radiation from the sun to heat special panels which transfer the heat to water which can then be used by homes. It can also generate electricity by powering photo-voltaic cells (much more expensive solar panels).

Biomass comes in many forms, but originates from plants. Oils from palm, rape and other seeds can power internal combustion engines and can replace or supplement diesel. Wood pellets can be burnt in furnaces to heat water for buildings or to generate electricity at power plants. Waste plant material can be used in 'digesters' to produce methane gas which can then be burnt for heat or to generate electricity. Biomass is virtually carbon neutral because the plants have absorbed carbon when growing and this is released on combustion. More plants then absorb this and so it goes on.

Electricity and district heat is produced from one or more of the above energy resources. It still contributes to the emission of carbon dioxide (CO_2), sulphur and nitrogen compounds when combustion is used.

Required materials:

- Access to energy meters or weekly consumption totals from school site staff;
- Outdoor thermometer;
- Internet connection for registering the results in the http://sustain.no online database;
- Timetables of school use by outside users and the school itself.

Required pupil skills:

- Meter reading*,
- Measuring temperature in Celsius*
- Understanding and creating tables and graphs*
- Using on-line data-base*
- Knowledge of Area and how to calculate it*
- Knowledge of kWh
- Comparing and contrasting weather and climate from other countries**,
- Comparing and contrasting school buildings and types of energy production from other countries**
- Putting together presentations to show results to others**

* Minimum requirements (obviously the age/ability of the pupils will determine their actual involvement).

** Possible extension activities.

How does this activity fit into the curriculum:

This activity is well suited for lessons in mathematics, science and geography. Extension activities can include valuable literacy skills e.g. speaking and listening, putting together a presentation for others, etc.

Safety issues:

Depending on where the energy meters are located the pupils may need to be accompanied by an adult.

Individual steps of the activity:	Required time:
1. Agree with the school caretaker and the school management how the pupils are to gain access to the necessary information on energy consumption. 2. Modify the tables shown in Aid 1, 2 and 3 to fit your particular needs depending on the type of energy consumed, accessible meters, and available billing information. It is advisable to consult the school caretaker	Preparation – A meeting with the school caretaker and school management.

for information on the special conditions at the school. Alternatively, this can also be done by the pupils themselves. 3. Register with http://sustain.no (see Aid 4 for instructions on how to do so). Alternatively, this can also be done by the pupils themselves.	
4. Explain the exercise to the pupils. 5. Divide the class into four groups (one for each season) each taking its turn in collecting and registering data. Alternatively, a number of groups could work in parallel registering the same data. The latter will ensure that all are involved in the entire process and you can use the opportunity of multiple readings to spot incorrect meter readings and calculations.	Introduction – ½ lesson
6. Accurately determine the school energy consumption ➢ The group(s) of pupils responsible for determining the school energy consumption must have access to energy consumption figures or energy meters. ➢ It is the total of all energy forms used, which must be registered each week (see Aid 1). ➢ Make sure the readings are taken at the same time every week, for example every Monday morning at 08:00. ➢ If the school uses only electricity for all its appliances including heating or cooling, it is easy to find out the consumption by reading the electricity meter. Bear in mind that the school may have several meters. ➢ If the school uses additional energy sources (oil, district heating, natural gas, wind power, solar energy, heat pumps, etc.) this consumption must also be registered. Some of these types of energy are not counted in kWh but in other units which must then be converted to kWh (see Aid 2). In some cases it is not possible to meter the weekly consumption of these energy types and the data must be found using for example quarterly energy bills. In many schools, the caretaker keeps regular energy accounts summarizing both electricity consumption and total energy consumption and will be able to supply the pupils with the necessary data if needed. Alternatively the school's energy supplier or a local energy agency could be asked for assistance. 7. Accurately determine the outdoor temperature ➢ Obviously the need for heating or cooling is related to the outdoor temperature. The need for space heating is significantly higher on a cold winter morning than on a warm summer day. It is therefore necessary to look at the school energy consumption in relation to the	Energy monitoring activity – 15 to 30 minutes once a week for the group(s) responsible for collecting the data.

outdoor temperature.

- The temperature can easily be measured with an outdoor thermometer placed in a position shielded from the sun. Make as many diurnal readings as possible, and try to do the reading at fixed times of the day throughout the week (e.g. every fourth hour). Calculate the average temperature for each week using Aid 3.
- In case you encounter problems with your temperature readings one week then you can most likely obtain an alternative set of data from your local or national meteorological authorities who register the average temperature on a weekly basis.

8. Calculate the specific energy consumption

   - The energy consumption of a large school is likely to be much higher than that of a small school. The area that needs heating or cooling is larger and the number of toilets, sinks, showers, lights and electric appliances is larger because more children attend the school. In order to compare measurements from different schools, the specific energy consumption must be found. The school's specific energy consumption is the total energy consumption divided by the heated or cooled area (kWh/m^2). The heated area is defined as the total floor area in all rooms with temperatures exceeding 15 °C (i.e. discounting rooms such as lofts, cellars and cold stores). The cooled area is defined as the total floor area in all rooms with air condition equipment installed.
   - Although some rooms might be both heated and cooled their area is not counted twice.

9. Determine the activity level

   - Also, the activity level at the school influences the energy consumption. If a significant number of the student's are away on a school trip, the energy consumption is likely to be lower that day or week. If the school premises are used for extra evening classes after normal school hours then the energy consumption is likely to be higher that day or week. It is therefore necessary to note down changes in the activity level on the school premises. This can be anticipated by looking at school timetables.

10. Register the data on http://sustain.no

    - When the data has been collected it is entered in to the database on the website http://sustain.no. On this website it is possible to view the results by means of automatic graphic display, compare the results with those from other schools and get feedback from other schools.

➢ Aid 4 describes how to use the website.	
11. First the pupil's own data is discussed. Later the data can be compared to that of other schools. Examples of discussion topics could be: ➢ Does energy consumption go up with falling temperatures? ➢ Does energy consumption go down with increasing temperatures? ➢ How does the energy consumption change from season to season? ➢ What could be the main end-uses contributing to the energy consumption? ➢ How much does the school energy bill amount to? ➢ How much CO_2 emission does the school energy consumption result in? ➢ What is the school energy consumption level compared to that of other schools? What could be the reasons for the difference? 12. If you are not comfortable leading the discussion you can invite the caretaker, a colleague, older pupils or an expert from the local energy agency to explain the possibilities for the changes and differences. Prior to the visit, the pupils could prepare a list of questions that they would like to have an answer to.	Analysis and reflection – 1 lesson
13. The pupils prepare a presentation of their findings and give a presentation. The possibilities are many. The pupils could prepare a report and send it to a friendship school, school management, or the local authorities. The pupils could also give an oral presentation to the other classes or make an exhibition stand.	Presentation – 1 lesson

Suggestions for combination with other AL activities:

"The energy house" – The pupils test the importance of the building envelope relative to energy consumption.

"Special energy investigators" – The pupils experiment with three types of heat transfer, namely conduction, convection, and radiation.

"Ventilation aspects in schools" – A very hands-on exercise that allow the pupils to identify drafty windows and find out how to reduce the draft and the associated energy waste.

Variations:

Simpler exercise:

If the target of the exercise is younger children, then more of the energy consumption measurements can be placed with yourself or older classes. The pupils then measure the outdoor temperature and help plot all data in a chart mounted on the class room wall (see Aid 5). The important thing is that they get a visual impression of the changes in energy consumption levels. You may also need to do more activities from the tool-kit to enhance understanding.

Involvement of the entire school:

The exercise is well suited as a basis for raising the profile of energy conservation within the school. The results can be presented to all school stakeholders so that everyone can take responsibility for saving energy by adapting their behaviour.

Limited access to energy data:

If you only have limited access to energy data for example only weekly information on electricity consumption, we suggest that you try one of the other active learning activities instead.

Available aids:

Aid 1 – Data collection sheet[1]

Aid 2 – Calculating kWh content of various energy sources

Aid 3 – Table for calculating weekly outdoor temperature

Aid 4 – How to register data on http://sustain.no

Aid 5 – Energy chart

[1] If any of you partners wish to do so, you are welcome to insert your own data tables or links to such tables instead.

Monitoring school energy consumption – Aid 1

Names of pupils in the group:	

Year	Week	Date	Weekly energy consumption	Specific energy consumption	Mean weekly outdoor temperature	Activity level			Comment
						Higher	Normal	Lower	
			kWh	kWh/m^2	°C				
			kWh	kWh/m^2	°C				
			kWh	kWh/m^2	°C				
			kWh	kWh/m^2	°C				
			kWh	kWh/m^2	°C				
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			kWh	kWh/m^2	°C				
			kWh	kWh/m^2	°C				
			kWh	kWh/m^2	°C				

The energy for the school is measured and the measurement used as basis for the energy bill. There is for example minimum one electricity meter in the school measuring the electricity consumption. The meter is read either by school staff or the energy supplier.

Some schools transform the energy received from the energy supplier into another form on site, for example oil into space heating and hot water. This is most often done centrally and the energy then distributed to the relevant rooms of the school. The energy conversion can be more or less efficient depending on the operational state and type of conversion system (for example the boiler) and the distribution system.

The aim of the energy monitoring is among other things to form the basis for finding ways to reduce the school's energy consumption level. **The energy monitoring activity is only concerned with the consumption of energy delivered to the school by the energy supplier.** However, if significant changes are made to the conversion system or/and the distribution system in the school then this will have an impact on the energy consumption level and should be noted. For example, if the oil boiler is replaced by a more efficient boiler and the hot water pipes better insulated, then energy consumption will fall – not as a result from the pupils and school staff lowering the room temperature and using less hot water but because the losses on the way from energy supplier to the end-users are reduced.

kWh (kilo-Watt-hours) is the unit in which electricity is typically measured. In order to be able to add the consumption of the various energy sources together to form a total, they need to be in the same unit of measurement. **The most important thing is to use the same method for the duration of the energy monitoring.** You therefore need to convert litres, kg and m^3 into kWh. It is not so important to get the values extremely precise since the aim is to follow the change in consumption over time and not to determine the level with great precision.

The table below shows the general energy content of various energy resources, which can be used in case you do not have access to more accurate data from your energy bill, caretaker, energy supplier or local energy agency.

Example on how to calculate the kWh content of natural gas:

1,000 Nm^3 natural gas = 1,000 m^3 * 11.5 kWh/Nm^3 = 11,500 kWh

Energy source	Approximate energy content
District heat	1,000 kWh/MWh
Natural gas	13 kWh/kg (11-12 kWh/Normal m^3)
Oil (light fuel)	12 kWh/kg (10 kWh/litre)
Paraffin oil	12 kWh/kg
Wood (pellets)	4.8 kWh/kg
Propane	13 kWh/kg
Electric heat pump	1 kWh/kWh
Electric cooling device	1 kWh/kWh

Table for calculating weekly outdoor temperature

Names of pupils in the group:

Year	Week	Date	Time	Temperature	Average
				°C	°C
				°C	
				°C	
				°C	
				°C	
				°C	
				°C	
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How to register data on http://sustain.no

The first step in registering your measurements on sustain.no is to register your school as participant. You will need an email address to which confirmation of access can be sent. The site operator usually responds within a day.

To register as participant the first time:

Click "Energy" on the home page;

Click "Check the school's energy use";

Here you find "Read the guidelines", "Enter data" and "Show results";

Click "Enter data";

Click "New participant";

Select country and click "Continue";

Follow instructions.

Once you have received a confirmation by email, you can type in the **basic information about your school**:

Click "Energy" on the home page;

Click "Check the school's energy use";

Here you find the options "Read the guidelines", "Enter data" and "Show results";

Click "Enter data";

Here you find a list of registered sites/schools. Click on your site/school.

If you do not find your sites/schools, click "Register a new site" and follow instructions.

Enter information on country, site name (the name of your school building), region (municipality), short description of site (not necessary), enter heated/cooled area (in m2), swimming pool (yes/no).

The area of your school is used to calculate the energy consumption per m^2, called the "specific energy consumption". Schools vary among other things in sizes and by calculating the energy consumption per heated/cooled m^2 it becomes possible to compare your data with that of other schools. The heated/cooled area of the school is not the only indicator of the likely level of energy consumption (for example, the type of building envelope and the number of pupils also matter) but the area is the most important indicator.

Now you are ready to start **entering your measurements** (every week):

Click "Enter data";

Click "Select a site" (the school);

Click "2007" (the year for the registration);

A table then appears into which you can type your data;

Fill in the table;

Click "Register data".

Once you are finished typing in three or more data sets a report is generated and you can review the data in graphic form. To see the report/graphs click "Show data";

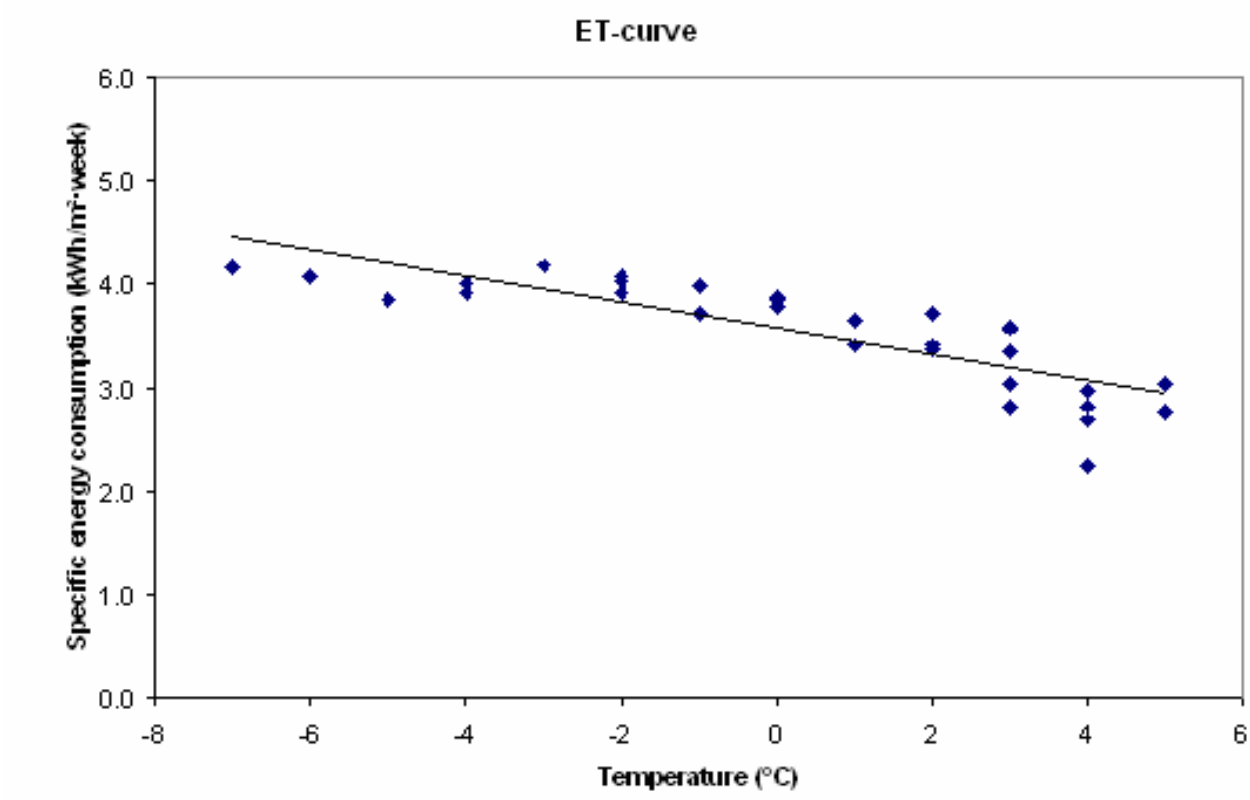
Choose the period you want to look at data for;

If you click "display all" and three or more registrations are made for the school the following appears:

- An energy-temperature curve – Shows your entries in graphic form (dots) together with a straight line. The straight line is calculated by the programme and represents your school's mean specific energy consumption.
- Energy consumption and the energy-temperature curve – A table showing your expected annual energy consumption compared with the buildings energy-temperature curve, calculated by the programme.
- Weekly energy consumption – A graphic presentation of your data entries regarding energy consumption level;
- Specific energy consumption per week – A graphic presentation of your data entries regarding specific energy consumption level;
- A table of your entries.

Your school's energy consumption will be plotted as an ET-curve, where the "E" stands for energy consumption and the "T" for temperature. The x-axis represents the average weekly temperature while the y-axis shows the school's energy consumption. Each set of data (outdoor temperature and specific energy consumption for a given week) is shown as a dot. The straight line is an estimate (calculated by the computer) of the relationship between outdoor temperature and specific energy consumption. In other words if the outdoor weekly temperature is minus 4 °C the curve shows specific energy consumption level you can expect to find that week. The curve is a useful tool for understanding the energy consumption and discovering deviations that cannot be explained by temperature conditions. The ET-curve is unique for each building and is best calculated on the basis of long-term measurements – ideally weekly measurements for an entire year.

An example is presented below.



Having typed in data of your own, you can then go on to **compare your measurements with those of other schools**:

Click "Compare schools" and choose the school for comparison.

All your data and that of other schools are automatically put together and the mean specific energy consumption of all schools together calculated. To see this information for your nation, click "Compare a school with the national mean".

Please keep in mind that the more data you enter the more accurate the results in terms of your own site and the comparisons with other sites.

(The site operator continuously works to improve the site. Should you have any comments or ideas for improvement then please do not hesitate to notify the site operator post@sustain.no)

Energy Chart

[Insert link to file]

Search words:

Energy end-use	General topic	Educational subject	Age level
Transport	**General sustainable development**	**Mathematics**	6-8 years
Space heating & cooling	Renewable energy	**Science**	**9-10 years**
Hot & cold water	Energy efficiency (saving)	Etc.	11-12 years
Lighting	CO_2 wise transport		
Electric appliances			