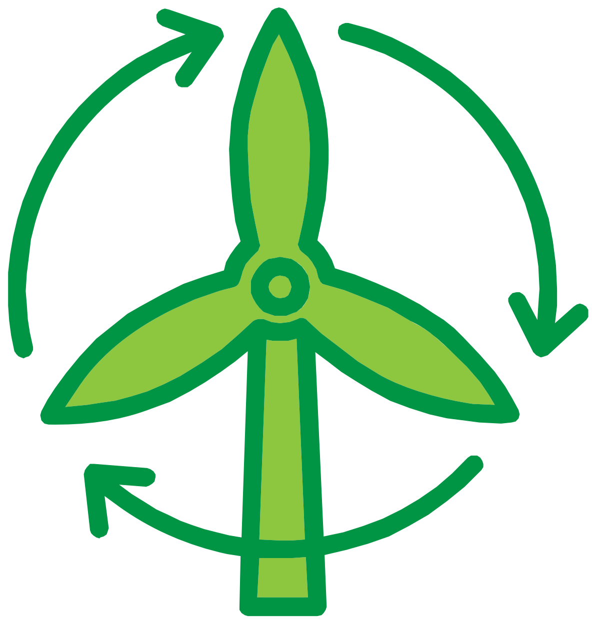
Sustainable Energy



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Teacher's Notes

This unit builds on students' knowledge of non-renewable and renewable energy resources. It allows students' to review energy mix and demand and investigate the viability of the use of different renewable energy resources in the Cevennes National Park. The Eagles Nest Centre is very aware of environmental impact and is making huge efforts to reduce waste and save energy. The aim of this unit is to investigate how successful the Eagles Nest is at saving energy and its potential to harvest energy from the surrounding environment. There will also be the opportunity to visit a wind farm and a Bio fuel plant all within one and a half hours of the centre. Field work will include visiting 3 different sites to assess whether a wind farm, solar energy or hydroelectric plant would be successful in producing enough energy to make them viable. Students will be able to calculate energy produced and assess the positives and negatives for renewable energy resources. Through assessment of the centre they will become familiar with possible sites for energy loss and area of improvement. This unit allows student to investigate a global issue on a local scale. Theoretical and practical aspects of the unit will concentrate on power policies and usage in France.

Key Specification links

WJEC A2 Geography

Theme 3 Sustainable Energy

Edexcel A2 Geography (9GE01)

Unit 3 Contested Planet

Topic 1 Energy Security

OCR AS/A Level Geography

AS Unit F762 Managing Change in Human Environments

The energy issue

AQA AS and A Level Geography (2030)

Unit 1 Physical and Human Geography

Optional human topic Energy Issues.

Bibliography

www.carbonfootprint.com

www.foundation.org.uk

www.michaelbluejay.com

www.eia.doe.gov

www.berr.gov.uk

Ministère de l'Économie, des Finances et de l'Industrie, DGEMP, modifié le 20/11/2006

The Economist

Introduction

Resources are anything that humans need or use. They can be non renewable, having a finite supply, or renewable meaning they can be used repeatedly. The sun is the primary source of energy for the earth and the energy for industry, transport and domestic use was traditionally generated from fossil fuel which is an ancient store of the sun's energy. In 2006 coal (26.5%), oil (37.3%) and natural gas (23.9%) accounted for 87.7 % of all energy used globally. Fossil fuels are easy to use and develop but are polluting. Also fossil fuels take millions of years to form. It was estimated in the 90's that at the rate of consumption the fossil fuels used in one year would take 1 million years to replenish. Resources are also unevenly distributed with some countries have a bigger percentage of certain fossil fuels and some having none.

Everyone is affected by the massive ongoing debate regarding energy consumption, efficiency and conservation. Be it global warming caused by human activity or be it natural climate change, reduction in carbon emissions is a must and it is a fact that non-renewable energy resources are running out. In 2004 BP statistics stated that at current use oil will last for 40.5 years, coal will last for 164 years and gas for 66.7 years. Since the mid 1900's the use of renewable fuel has increased and in 2006, nearly 18% of the final global energy consumption came from renewables. When assessing the need for an energy change many things must be considered. Firstly what is the fuel mix of the country? This means what type of fuel is already being used and what percentage of the country's output is renewable and non-renewable. Secondly has the country got the technology and access to enough wind, sun or water to allow them to take advantage of non renewable energy sources. The carbon emission must also be considered and finally a SWOT (Strengths, weaknesses, opportunities and threats) analysis must be completed when considering the switch to renewable fuel. Although renewable fuel sources will never run out there are still problems associated with them. For example destroying habitats and causing visual pollution and the resources needed to build and maintain the renewable energy sites.

There is also the argument that instead of the development of alternative energy sources we must simply reduce our energy consumption. Be it through energy saving appliances or through increased and better quality insulation. By lowering the demand of energy the supply should last longer. However this is by no way a long term solution. Sources of energy are dependent on:

- Availability, quality, lifetime and sustainability of the proposed fuel;
- Cost of harnessing and transport;
- Technology needed to harness it;
- Demands of final user and competition;
- Size and affluence of the market;
- Accessibility of local market place;
- Political decisions and environmental bodies, be it national or international, eg. Greenpeace.

Specific Information

The UK was the first country to industrialise mainly due to its exploitation of coal reserves. Natural gas was discovered in 1965 and oil in the North Sea in 1970. It is estimated that the UK has about 300 years of coal and 40 years of natural gas left. In 1999 Britain was the 6th biggest oil and gas producer. It is now 12th. However 30,000 people are still employed by these industries. Britain must now look to renewable energy sources and because of the weather, wind and wave power are much more feasible that other renewable energy sources.

With a population of 62 million France represent 1% of the worlds population and 0.1% of the worlds land mass (544,000 sq. Km). Energy consumption accounts for 2.5% of the worlds total primary energy supply (TPES) with each capita consuming 4.7 toe (metric tons of oil equivalent) in 2005. Despite this huge demand France has only 0.01% of the know world fuel reserves (23 million tons). Therefore France is very poor in energy resources in contrast with European countries. However it is the 7th biggest consumer of energy with a demand of 275 million tons consumed in 2004 therefore showing a fuel deficit

The coal production in France dropped dramatically in the 1970's from 40 million tons per year to just 3 in 2003. The last pit closed in April 2004 (Creutzwald, in Lorraine). Natural gas is supplied by the field in Lacq which since 1951 exploited a large natural gas reserve under the city producing is gradually reducing and the supply is only expected to last until 2013. Oil production is low with just 1.5 million tons produced per year. France relies heavily on renewable energy and on nuclear. Dams have been constructed and there are 58 nuclear power reactors. The change to nuclear occurred in the 1970's (Ministère de l'Économie, des Finances et de l'Industrie, DGEMP, modifié le 20/11/2006)

Non renewable energy sources:

Coal: Coal provided the basis for Industrial revolution and is still the most exploitable of all resources despite being mined for over 2 centuries. Over the years of mining technology has increased and therefore productivity. The coal industry is now very capital intensive and deeper mines mean few workers. There was a massive reduction in mining in 80's and 90's and no new coal driven power stations are to be built in the UK. France has also seen a massive decline and now imports more coal than it produces. All the coal that is easy to access has been use up.

Oil: Oil is the world's largest business it causes conflict and gains the most media coverage. Oil is expensive and the price is now $137 / barrel (June 2008). The cost has increased by 76% since 2000 and is forever increasing causing fuel strikes and protests. There is increased demand in developing countries and because of this there is a call for increased production and tax cuts. Oil is expensive to extract and there is a danger of oil tankers running aground, which can cause water pollution and harm sea mammals and birds. Oil is hard to distribute because of the possibility of such accidents and the massive expense and bad publicity associated with clean ups. Huge overland pipelines offer extended environmental risks.

Natural Gas: Natural gas is the cheapest and cleanest of all fossil fuel and in 1998 it contributed to 25% of the worlds energy mix. As stated above the reserves of natural gas is 66.7 years with most of the gas reserves located in the Middle East and Russia.

Nuclear Power: The largest debate in energy circles is the use of nuclear power. France is one of the world's leaders in nuclear power with it accounting for 42% of the energy mix. Britain has treated nuclear power with more caution still in 1956 the first British station was opened, with nuclear power reaching its peak in 1990 with nuclear power contributing to 30% of Britain's fuel mix British has 19 nuclear reactors which generate 1/5 of Britain electricity one of these will be retired in 2023 but more are expected to be built in 2017. Nuclear power uses the break down of the radioactive element Uranium to make energy. There are many risks involved in nuclear including routine emission of radioactivity, waste disposal of hazardous material and contamination accidents. Nuclear waste has a massive half life which means it takes a long time to break down. For example plutonium has a half life of 250,000 years. There has already been 2 massive accidents in 60 years of nuclear power. The first at Three Mile Island in the USA in 1979 and the second being Chernobyl in the Ukraine in 1986.

Renewable Energy Sources:

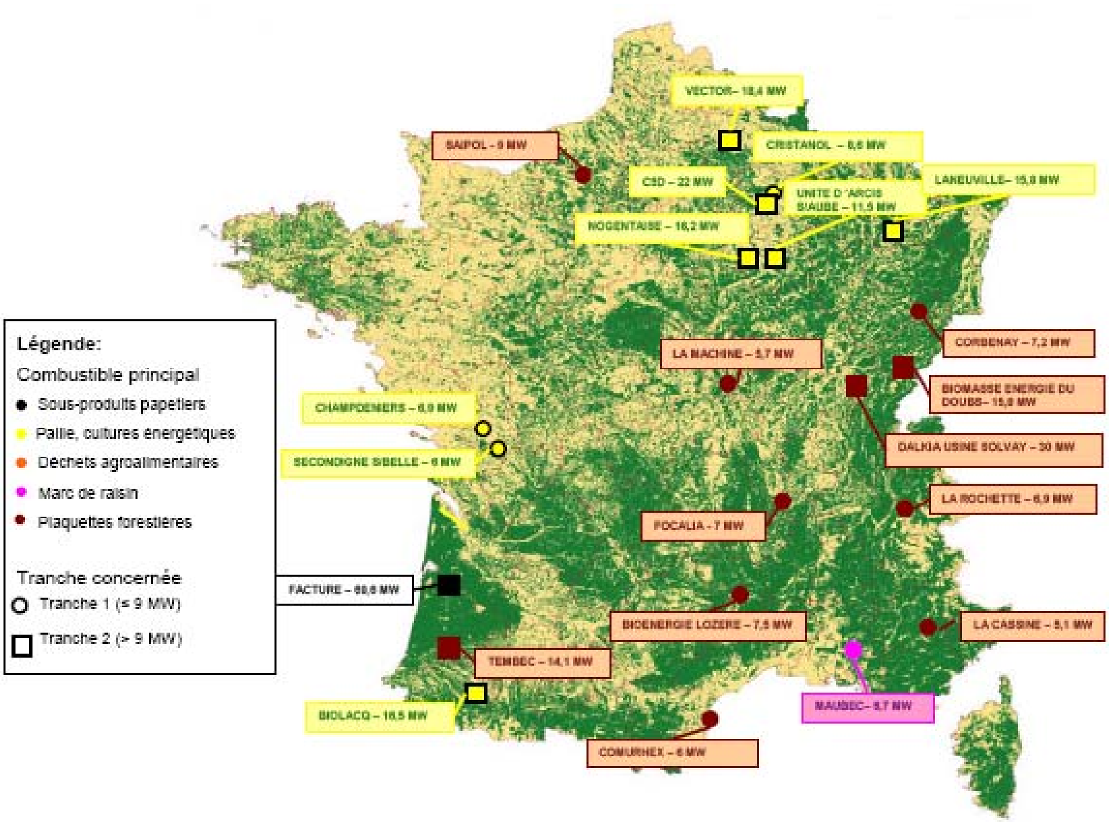
Hydro electric power: Hydro electric power relies on the constant flow of water produced by rainfall or artificially produced by a dam. They have a very high set up cost, but are relatively cheap to run after this initial investment. New dams can cause loss of agricultural land, increase flood risks and effect habitats. This unit will investigate the potential of using hydro electric power to produce energy to run the Eagles Nest study Centre. To do this it is proposed that the River Soutayran is dammed. Hydro electric power relies on potential energy of dammed water and its ability to drive a turbine. Energy produced depends on the discharge of the water and on the height difference between the source of the water and the outfall. To obtain very high head, water for a hydraulic turbine may be run through a large pipe called a penstock. Groups will be able to obtain the discharge of the river and through calculations estimate the size of dam needed to produce enough energy to power the 4 classrooms at the centre. Students will also have access to past discharge figures of the river over a one year time period.

Wind power: Wind power is produced both on a large scale by wind farms as well as individual private turbines. The large wind farms feed into electricity grids. Wind power has many positives including being clean and non CO2 producing, however the intermittency of the wind can cause problems. The main disadvantage of wind energy is the generation of the electricity from the turbines may not necessarily relate to the periods of demand on the national grid so the electricity needs to be stored in capacitors/ batteries. Wind power is very underused. Turbines are expensive to build and maintain and very capitally intensive.700 turbines is the equivalent to 1 nuclear power staion. They can cause visual pollution and habitat destruction. However many places have strong wind in the winter when demand is high for electricity therefore wind power is a viable option. Wind power as a means of generating electricity will also be examined. Students will visit 3 sites within walking distance of the Centre. They will measure wind speed and calculate the size of wind turbine needed to produce enough energy to power the 4 centre classrooms. They may also visit one of the wind farms in the department of Lozere and assess its physical impact on the environment. Currently wind produces 1% of the worlds energy but has increased five fold between 2000 and 2007. Students will again have access to a years data set for wind speed at the Centre.

Solar power: Solar power is the conversion of sunlight into electricity. The solar energy received from the sun is capable of providing 15,000 times more energy that the total global demand. It is safe and efficient and pollution free. Solar power is very advanced. Many buildings have solar panels, solar power can be used to heat water, cook food, distillation and disinfection. Even small devise such as calculators and watches can be solar powered. Solar power is much more available for domestic use and cost of set up is falling. Equipment is available at the centre which will allow students to calculate whether it is possible to incorporate solar power into the centre's energy mix.

Wave power: This source of energy has massive potential . Only sites of maximum tidal range offer possible sites. Economic and environmental costs are high including permanent flooding or marsh land. Technology has been very slow to develop with Stephen Salter's Wave Generator being stalled by lack of funding and opposition from other sources. New technology is on it way but is very unpredictable and slow to develop. In October 2007 the first commercial wave farm was opened off the coast of Portugal. One is also planned of the coast of California in 2012.

Biofuel: This is anything be it solid, liquid or gas that is derived from dead biological material. Biofuel is produced by any biological carbon source. Biofuels are used globally and it use in expanding in Europe, Asia and America. Sustainability of biofuel is a key issue when discussing its use. Student will have the opportunity to examine the development of a biofuel plant near Mende which produced 7.5Mw of electricity and 32Mw o thermal power. This will help student formulate pros and cons and raise key issues for biofuel. Such as whether it reduces carbon emissions, if it causes deforestation and whether potential food sources should be used for fuel instead.



Map 1 Biofuel Plants in France (2008)

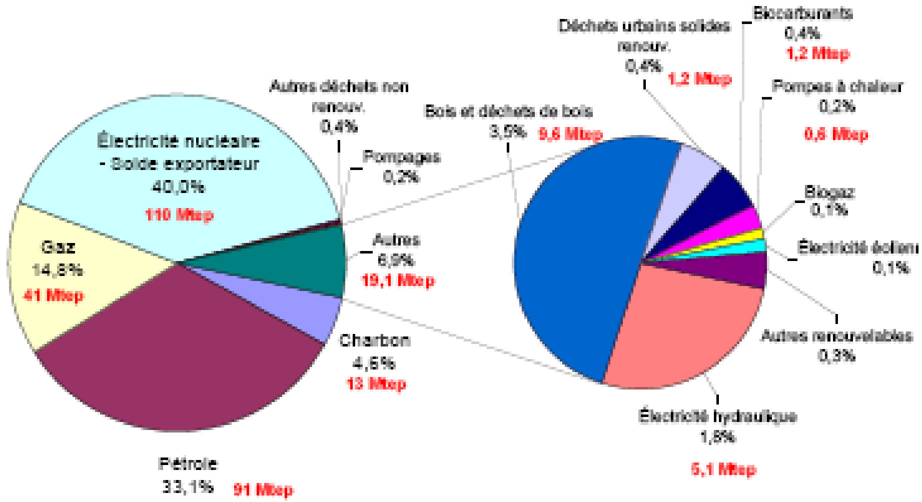


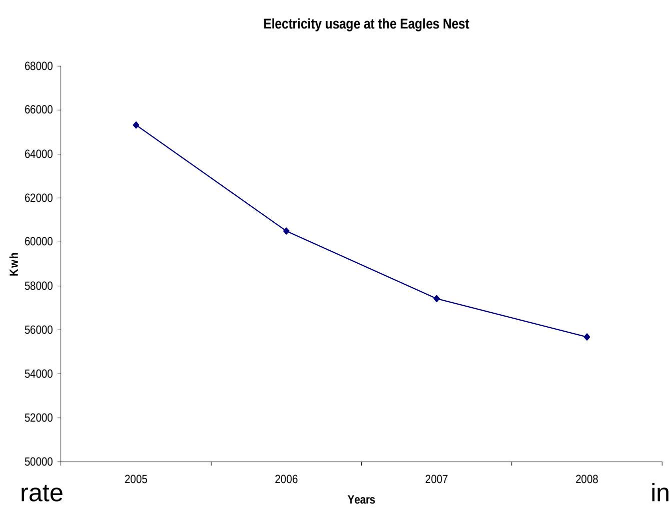
Figure 1 Energy use in France, with contribution made by biofuels.

Currently Biofuels, including domestic and industrial waste are the greatest source of renewable energy within France (3.5%), exceeding both hydroelectric and wind power.

The Eagles Nest energy mix

The Eagles Nest has a very high energy demand. The centre can hold over 100 people at full capacity and all lights and computer, gas cooker and heaters must be run off the centre energy mix of gas and electricity. The centre is over 50 years old so has old fashioned single pane windows and poor insulation. Student will assess the efficiency of the building for one of the practical aspects of the unit.

Gas is used for a number of tasks mainly where it is more efficient than electricity or to reduce overall electricity demand. The gas tank is 4000 litres and in spring/autumn when it is necessary to heat the centre for groups up to 20% of this gas is used weekly. In the summer demand drops and only 5% is used.



Electricity is supplied through the national company of EDF. The Eagles Nest uses a system called “Option Tempo” which is somewhat complicated but allows EDF to reduce demand at peak periods. This classifies each day by a colour, red (22 days), white (43 days) and blue (300 days) and has cheaper rate electricity between 10.00pm and 06.00am. The advantage is that for blue days the electricity is at the cheapest possible rate in France, white days are at a normal rate, but for a red day the cost goes up by a factor of 10. However red days are only allowed between 1st September and 1st of March and notice must be given the day before each assigned day (this can be done through email, text alerts or a light in a socket). On these days the most people and companies try to reduce energy usage to reduce costs. This allows the company to cope with potential peaks in energy demands.

Small businesses and domestic users will contract for a certain amount of electricity, between 3 and 36Kw, the lower the value the lower the standing charge. If we pull more power than the contract the electrical system will trip out. The Centre has a maximum pull of 36 kilo Watts this is why the centre can experience power trips when people plug in too many electrical appliances at once. The Centre's electricity consumption has reduced in the last 4 years. Between January 2007 and January 2008 the Eagles Nest consumed 55683 Kilowatts. This figure is important for future calculations. The electricity is provided by EDF. They are an electricity company which is trying to reduce its carbon emissions and plan to use 10% renewable energy.

Aims

- To review key energy terms.
- To consider the centre's energy mix.
- To assess the viability of non renewable energy resources at the eagles nest.
- To consider the Eagles Nest's energy efficiency and identify improvements.
- To understand and apply the term carbon foot print on a personal and grander scale.

Objectives

- Calculate the energy demand for the Eagles Nest
- To investigate the best location for a wind farm on Mont Lozere
- To determine whether the river Souteyran velocity is high enough to make it a viable hydro electric site.
- To investigate areas where energy consumption could be reduced and efficiency increased.
- Assess the success of 2 existing renewable energy plants in the department of Lozere.

General observation to be made

- The Eagles Nest can make a high demand upon energy.
- Decisions made by visitors to the centre can affect the amount of energy used.
- Demand will depend on weather and number of people staying at the centre.
- The centre only operates for part of the year, so comparatively little energy is used during winter.
- The sites visited will provide differing positive and negative for renewable energy through assessment of number of turbines and a visual impact assessment.
- The river Souteyran discharge will mean that to produce enough power to run the centre the dam built would be so large it would have a negative impact on the river both aesthetically and physically. Plus, the Centre is located in a national park so planning for a wind farm and hydro electric plant would be impossible.
- To improve the centres energy efficiency by reducing heat loss would be expensive and ineffective for much of the year.

Data Collection Sites

All data collection sites are within walking distance of the Eagles Nest Centre. An 2 hour coach journey is required to visit the wind farm and bio fuel sites (Near Mende).

Equipment

Tape measure
Metre Ruler
Flow metre
Chain
U-tube
2 Ranging poles
Anemometer

Method and Organisation of Study

Task 1 -assessing energy demand and efficiency of the Eagles Nest

In small groups the class will tour the Centre and record the number of different appliances in all the areas they will use during the week including dining room, common room and classrooms. They will then sum up all the appliances and calculate power demand of the classrooms for 1 hour. This calculation will provide the basis for the rest of the day. They will identify sites within and around the building that cause loss of heat.

Task 2 – calculating hydro electric potential for the river soutayran

1. Present flow Cross-section

Measure water surface width and divide into 10 equal intervals – i.e. divide the width by 10. This will mean that you take 11 depth readings. Your first measurement should be taken directly against one bank and your last measurement should be taken against the other bank.

At each of the 11 sites measure depth.

Calculate the mean depth.

Cross-sectional area is calculated by multiplying the width by the mean depth.

2. Bank-full Cross-section

Measure the width of the channel.

Measure the distance from the tape to the water surface. This value is added onto the present flow depth reading (normally once the mean has been calculated). The tape must be held taut and horizontally at bank-full level.

Cross-sectional area is calculated by multiplying the width by the mean depth.

3. Using a Flow Metre/Impellor assembly

Measure the width of the stream and divide into 4 equal intervals (this will provide 3 measuring points – ¼, ½, & ¾ across the channel).

At each of these 3 points measure the velocity –set the impellor at ½ of the water depth and ensure that it is pointing upstream. Make sure that you stand downstream of the impellor when taking readings!

Record the time taken for the impeller to move from start position to finish position.

Calculate the velocity using the formula or chart.

Calculate the mean velocity for the station.

4. Gradient

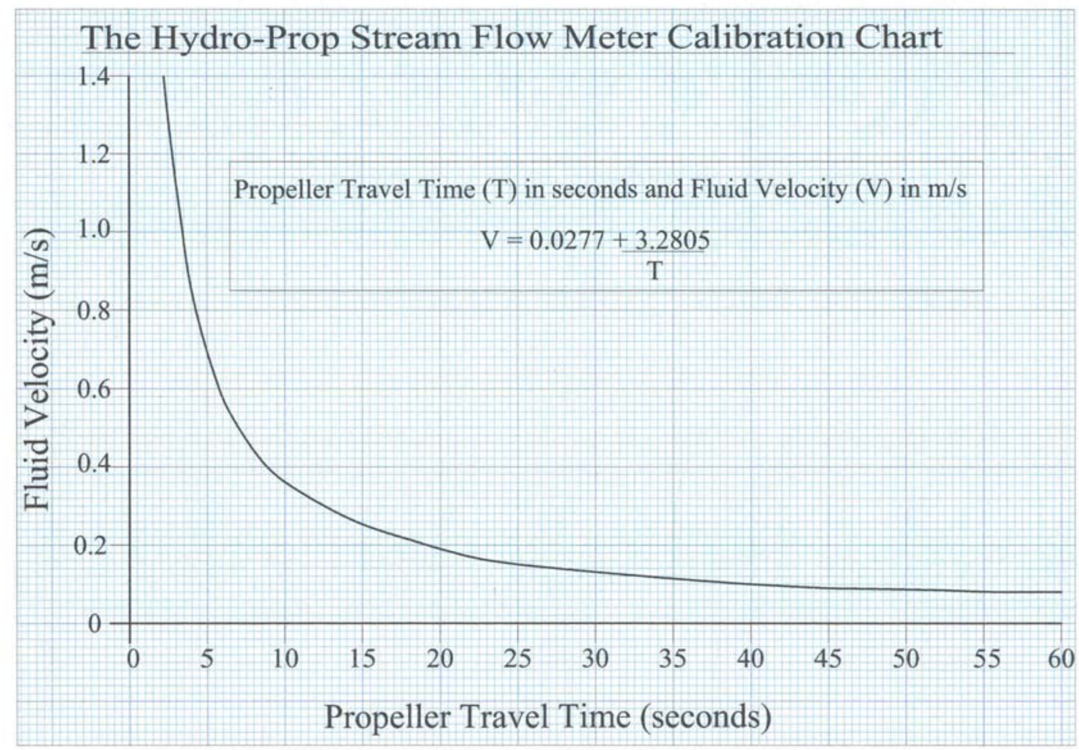
Half fill the tube with water and then place in the stream so that the rulers are 2m apart.

Read off the water level on each ruler and calculate the difference

5. Wetted perimeter

In the same location as the cross-section, run the chain along the bank and bed of the stream following all the contours of the channel. This gives the wetted perimeter at present flow levels. Measure the length using the tape measure. Note that the wetted perimeter is always greater than the width!

To find the bank-full simply measure the two sections of bank from the surface to the bank-full level and add this onto the previous reading.



Task 3- calculating wind speed

The group will visit 3 locations in the surround area of the Eagles nest study centre. The sites will include the Eagles Nest, Roc De Montal and the summit of Mont Lozere. At each site they will:-

- Measure the wind speed 5 times (every 5 minutes)
- Complete an environmental impact survey.

Calculating the blade size (area) needed for each location:

A= 2P/ du3 a= Area of blade needed in m2 d= density of air (a constant of 1.2 kgm-3) u=wind speed m/s

Location	Wind speed 1	Wind speed 2	Wind speed 3	Wind speed 4	Wind speed 5	Mean wind speed	Size of blade required

Centre's Energy Demand

You need to tour the centre and visit all the areas, however do not enter other groups bedrooms or bathrooms. Record the appliances and lights in the table below.

Appliance	Power used (W)	Number around centre	Total power needed
normal light bulb	60		
energy saving light bulb	18		
strip lights	36		
desktop computer	60-118		
monitor	80		
printer	460		
video/dvd player	120		
satellite box	30		
tv	120		
stereo system	130		
water heater	2000		
dehumidifier	720		

Total power needed

In the space provided make notes on the possible sites for reduced efficiency around the building for example gaps in doors ETC...

Hydro-electric Power Available from the River Souteyran.

	Recording 1		
	Present Flow	Bank-full	
Width (w)			
Depth (m)		Measure from tape to water surface ……… Add to present flow mean depth	
Wetted perimeter(m)			
Mean Depth (m)			
Time Taken			
Mean Time			

Energy investigation results sheet:

	Present flow	Bank full
W (w)	m	M
Depth (d)	m	M
Area (A) (w x d)	m2	m2
Wetted perimeter	m	m
Velocity (v)	m/s	
Discharge (Q)	m3/s	

Discharge at present flow

The discharge is the cross-sectional area (m^2) multiplied by the average velocity (m/s) and is measured in cubic metres per second (cumecs). **Q =CSA*VELOCITY**

Discharge at bank full

This method is particularly useful for calculating discharge at bank-full levels since it is not usually possible to measure velocity under these conditions. By removing the area from the formula it is possible to estimate a bank-full velocity and obtaining a discharge using Manning's 'n'. This can be calculated using the following formula:

$$Q = A \times \frac{R^{0.67} S^{0.5}}{n}$$

Where Q = Discharge A = Cross Sectional Area R = Hydraulic Radius (Area x Wetted Perimeter)
S = Channel Gradient (Divide the height difference by distance) n = Manning's 'n'. (This is a constant – you will need to select the appropriate constant from the table below.)

Channel Type	Manning's n
Earth canal, straight	0.020
Artificial channel – shuttered concrete	0.014
Winding natural river	0.035
Natural channel <30m wide, sluggish weedy pools	0.070
Mountain rivers, cobbles and boulders	0.050
Major rivers >30m wide, clean regular	0.025

The power available (P) is proportional to the head (H) and the discharge (Q)

P= QH * a Constant

The constant is derived from the density of the water (1) and its acceleration due to gravity (9.81)
Therefore
P=QH*1*9.81
We need to rearrange this equation so we can work out the size of dam needed to harvest enough power to turn on all the rooms lights and appliances for one hour.

H= P/ 9.8*Q

P= Power need to power all common areas and bedrooms used by students (KW) Q= discharge (cumecs)
Worked example (FOR THE USE OF TEN 60 WATT LIGHT BULBS)

H=
P= 0.6 kw
Q= 0.33 (MARCH 2002)
h= 0.6/ 9.8*0.33
H= 0.6/ 3.234
H= 0.185 m

The Eagles Nest

Landscape Evaluation

1. Numerical System:

Impact on the landscape (a)	Score	Visual Appeal (b)	Score
Stands out clearly	+2	Attractive	+2
Stands out	+1	Good	+1
Little impact or invisible	0	Poor	-1
		Unattractive	-2

Landscape Component	(a) Impact on landscape	(b) Visual Appeal	Final score (a x b)
Vegetation Woodland Moorland Fields			
Physical features Hills Valleys Cliffs			
		TOTAL SCORE	

For this technique both objective and subjective measurements are used. The scores given by different people for the impact on the landscape of various components will probably be similar. However the visual appeal is much more of an opinion.

2. Descriptive System

Evaluate the landscape by drawing a circle around the word that you feel gives the best description.

SIZE:	tiny	small	large	vast
AREA:	restrictive	enclosed	open	exposed
BEAUTY:	ugly	plain	attractive	stunning
HUMAN IMPACT:	spoilt	artificial	natural	wild

Data analysis

The calculations above will allow student to assess how large their dam would need to be and how large a wind turbine's blades would have to be to produce enough power for the Eagles Nest classrooms.

The students will then be given a blade and dam size which is feasible for this area plus cost implications and energy demand of the entire centre 55683 Kilowatts annually. They will then be able to graph the water velocity and wind velocity needed to power either plan against the wind and water velocity available. For secondary data see appendices.

During the day student will also have visited 2 renewable energy plants, collected relevant data and assessed the efficiency of the Eagles Nest. They must now present all their data in a visual way and be prepared to discuss the positives and negative of each fuel type.

Additional Role play exercise

Scenario 1

The Eagles Nest has decided to purchase a wind turbine. It will cost £900 and produce 250watts of power. This energy can be stored. When fully charged the battery can run 5 power saving light bulbs (18 watts) for 22 hours. It needs a wind speed of 2.6 m/s. Is this idea workable?

Scenario 2

The Eagles Nest has found a supplier of solar powered lights. They will last 45 minutes and cost £12 each. They want to replace all the lights in the classrooms with these. Discuss how much this would cost and what the positive and negatives are.

Discussion

Intermittency

Pupil need to be aware that all renewable energy resources need to be backed up by either each other or by nuclear and fossil fuels. Solar energy and wind energy may show patterns that mean that if one is low the other is high. Students need to understand that there will always have to be a fuel mix. However the increase in renewable energy will take the pressure off fossil fuel and reduce carbon emissions.

Problems with storage and the possibility sharing fuel

Pupils need to understand that although turbines and solar panel can produce a lot of energy the energy is difficult to store. Once it is harvested most will be lost via heat. Renewable energy needs to be used very quickly after it is harvested. Future development needs to include the sharing of energy through the national grid. Meaning all fuel is utilised very soon after it is produced reducing waste dramatically. Some locations will have a deficit of solar power at some time of the year but may have a surplus in wind power. Sharing of this power will again make people less depended on fossil fuels. In time these should only be used in times of low renewable success.

Appendix 1

Average wind speed and average discharge for 2000

Wind speed (m/s)		January	February	March	April	May	June	July	August	September	October	November	December
	Max				15.1	11.6	22.2	14.3	8	9.4	8.7	9	10.1
	Min				4.9	3.7	4.4	5.2	1.4	1.6	1.2	1.3	1.2
	Average				7.7	6.5	9.8	7.8	3	3.3	3.7	3.9	3.7
Discharge cumecs													
	Max	0.2	0.3	0.35	0.76	1.08	0.28	0.12	0.12	0.8	0.79	0.79	
	Min	0.06	0.08	0.2	0.22	0.2	0.1	0.05	0.04	0.04	0.21	0.25	
	Average	0.12	0.17	0.26	0.45	0.49	0.18	0.07	0.05	0.09	0.45	0.52	

Average wind speed and average discharge for 2001

Wind speed (m/s)		January	February	March	April	May	June	July	August	September	October	November	December
	Max	11.3	11.6	8	13.1	7.1	8.7	7	8.4	6.8	9.1	12.2	11.5
	Min	0	1.4	1.6	1.3	1.3	1.7	1.1	1.5	1.5	1.3	1.6	1
	Average	3.4	5.3	3	4.7	3.4	3.5	3.1	2.6	2.5	2.8	5.3	4.4
Discharge (Q)													
	Max	0.32	2.73	0.51	0.38	0.76	0.16	0.1	0.07	0.05	0.65	0.21	0.06
	Min	0.23	0.16	0.18	0.13	0.14	0.08	0.05	0.04	0.04	0.05	0.06	0.04
	Average	0.27	0.31	0.33	0.2	0.3	0.12	0.06	0.05	0.04	0.19	10	0.05

Plan of the Eagles Nest: