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Fossil and renewable energy

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Theoretical note[1]

Energy has always been a vital issue for mankind and human societies. Human behaviour is, in fact, led to a significant extent by its availability or non-availability, its abundance or its scarcity. This conduct has in the past (and continues today) led to new issues, in particular for the environment and for socio-economic equilibrium.

It is our hope that being aware of the importance of these issues (climate warming, running out of resources, increases in healthcare, etc.) should make it possible to move towards a more rational use of energy, as well as making improvements in the energy-related processes that we use on a daily basis.

Basic logic

"Nothing is created, nothing is lost: everything is transformed". This assertion, attributed to Lavoisier, is the first principle of thermodynamics and the basis for all thoughts relating to *energy*.

This logic of things being transformed constitutes a genuine structure for viewing the world of energy. While energy is the ability to provide work, it is not possible to carry out any work without converting one form of energy to another. The quantity of energy in one particular system is a constant given and a firm characteristic of that system.

Energy conversion chains

To obtain a form of output or service, we always need to convert a form of *primary energy* into a form of usable energy.

If we want to have warmth, we have to start up a process for producing heat. For example by burning a fuel. Better still: we can do this by putting on a sweater to retain the heat given off by our body as it "burns" the sugar contained in our breakfast or uses up our reserves of fat. We cannot makes ourselves warm without converting some form of primary energy into heat. At the same time, we cannot feed ourselves indefinitely without converting this food into movement, heat, information, etc.

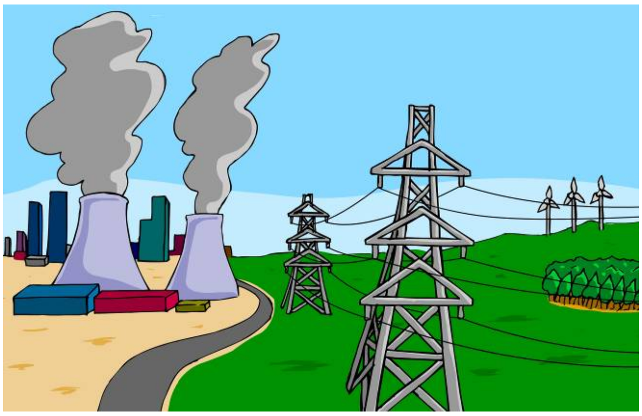

Figure 1 – Various facilities producing electricity[2]

To convert primary energy into something we can make use of, we call on numerous different technologies every day, some more consciously than others. These range from a simple battery to a nuclear power station, internal combustion engines or solar panels, each type of technology has its pros and cons.

We draw our energy at all times from the environment. In so doing, we modify it, often irreversibly. As consumers, we are at the end of the energy chain. Our behaviour will dictate whether or not a knock-on effect of other conversions and consequences will be set in motion.

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[1] The theoretical note for this educational file is a condensed version of a document produced by Cédric Jeanneret (Terrawatt – Energies for Sustainable Development – cedric@terrawatt.ch). The author has granted his permission for this adaptation, and we extend our sincere thanks for it.

[2] All of the illustrations in the file are taken from the animations at the Educapoles website: www.educapoles.org

Energy: quality and quantity

Why do we talk about an energy crisis when the first principle of *thermodynamics* states "nothing is created, nothing is lost"?

The thin end of the wedge is that conversions of energy cannot be reversed: with each conversion, there is deterioration in the quality of that energy. The processes used for converting energy, which involve various forms of energy in so doing, do not all have the same output.

Each conversion of energy results in losses and requires a greater level of energy quantity and quality than might be expected to fulfil the provision of that energy. Depending on the technologies used, these losses are bigger or smaller.

The energy contained in primary energies (crude oil, natural gas, etc.) is converted into energy end-products (petrol, electricity, etc.) so that it can then be converted again into consumable energy (heat, light, movement, etc.) before being finally and irretrievably dissipated into heat. At the current time, over half of energy is lost along the way during these conversion processes.

Renewable / non-renewable energy

The sun's intensity is not reduced when solar panels are installed, nor does the wind stop blowing when windmills are constructed. By contrast, our reserves of oil, coal, natural gas and uranium are irretrievably reduced when they are used.
Consequently, there are two major types of energy:

"*Renewable*" energies, which are part of a natural cycle. The availability of these forms of energy is not reduced when they are used.	"*Non-renewable*" energies, that run out when we use them (limited stocks).
The sun	Petrol
The basis of all natural cycles.	Produced from oil.
Plants	Heating oil
Plants grow and develop as the seasons go by.	Also produced by refining oil.
Hydraulic	Coal
Produced by the water cycle (sun + the force of gravity).	Extracted from mines.
Wind	Natural gas
Depending on the weather and the rotation of the Earth.	Natural, but not renewable.
Wood	Uranium
Produced by forests.	Formed at the same time as our planet, billions of years ago.
Other renewable energies	Other non-renewal energies
Geothermal, tides, biogas, ethanol, etc.	Jet fuel used in aircraft (produced from oil), butane, propane (also produced from oil) etc.

Traditionally, humans have lived by harnessing renewable energies (animal traction, wind and water mills, sailing, timber, not forgetting slavery...). Since the Industrial Revolution, man has extracted resources liberally from Earth's basement to obtain these non-renewable fossil energies that the planet has taken millions of years to form.

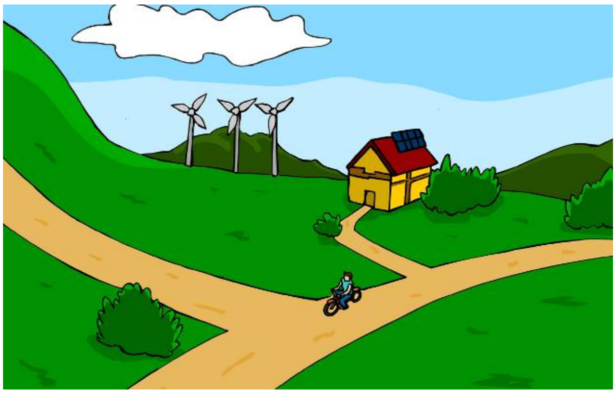
At the rate at which we are using non-renewable forms of energy, there will soon be none left. Or, to be more accurate, when the more accessible deposits have run out, we will need to prospect for more and drill under such difficult conditions that it will cost far too much for these resources to be exploited lucratively. Will that be in 20 years' time? 50? 100? 200? No-one knows precisely.

If we reduce the history of fossil energies to the symbolic period of a single year, the imbalance between the time required to form these fuels and the time in which they will be used up is startlingly clear:

Date	*Equivalent time taken over one year*	Events
300 million years ago	One minute past midnight on 1st January	**Formation of fossil energies begins**
200 million years ago	End of April	The dinosaurs appear
65 million years ago	Mid-October	The dinosaurs become extinct
23 million years ago	3rd December	Formation of the Alps
1 million years ago	Yesterday, shortly before 7.00 pm	First human types
300,000 years ago	9 hours ago	Man learns to make fire
40,000 years ago	An hour and a quarter ago	Homo Sapiens
0	3½ minutes ago	Birth of Christ
1750	25 seconds ago	The steam engine
1859	15 seconds ago	First oil well, Pennsylvania
1973	3 seconds ago	1st oil crisis
2003	31st December, midnight.	Now
2050?	in 5 seconds' time	End of proven oil reserves

Using renewable forms of energy also has an impact on the environment. These are far less extensive than the effects caused by our consumption of non-renewable energy, but they do exist:

- Dams: environmental and human impact (whole valleys flooded and drowned), impact on the river downstream, risk of the dam being breached, visual impact, *ecosystems* disrupted and even destined to disappear.
- Energy from wood: local impact on air quality. If use of the resource is poorly managed: deforestation, desertification, soil erosion and landslides.
- Wind farms: noise, impact on the landscape (ridges, hills).



Yesterday's renewable forms of energy	*Tomorrow's renewable forms of energy*
The sun	The sun (*solar panels, passive solar*)
Watermill, windmills, etc.	Hydroelectric turbines
Animal and human power (agriculture, slavery)	Wind farms
Sailing	Human power (bicycles, etc.)
Wood-fired cooking	Heating with wood shavings
etc.	etc.

Energy and the environment

Humans need energy to live and survive in their individual environments. All energy is taken out of the environment (energy resources). When converted, that energy performs a function and is then returned to the environment in a different form. The use of energy is now the number one factor in the changes happening to the planet.

By consuming huge quantities of mainly non-renewable energies (85% of the energy consumed in Europe comes from non-renewable sources), our industrialised societies are upsetting the balance of natural cycles and disrupting them in a way that is worrying and sometimes irreversible.

The main areas of impact on the environment caused by our consumption of energy are an increase in local pollution, the overall disruption of atmospheric and weather phenomena (global warming) and an increase in waste, especially nuclear waste.

Local pollution:

Every year, the smog breathed in by the people who live in Los Angeles is responsible for the deaths of 1600 of them. A study conducted by researchers in California, published in the *Science* journal in July 1992, estimated that the risk of dying as the result of atmospheric pollution in this city of 12 million people was one per thousand, or just half of the probability of being killed in a car accident.

- Winter smog: temperature inversions associated with emissions from heating systems and vehicles with engines create high levels of air pollution (nitrogen oxide, sulphur oxide, carbon monoxide, non-combusted residues, etc.).
- Summer smog: the sun’s radiation, associated with the heat and nitrogen oxide produced by vehicles with engines, creates high levels of ozone.

Waste:

Each year, nuclear power stations produce thousands of tons of waste with a low to moderate level of radioactivity, as well as tons of highly radioactive waste. The time it takes for the radioactivity in this waste to decay and become harmless – its *half-life* – is several tens of thousands of years.
Consequently, this waste has to be reprocessed and then stored. Every country that has nuclear power is faced with the complex problem of finding places to store this waste. It is an issue that still awaits a definitive solution.

Global warming and climate change:

The combustion of one ton of oil releases approximately 800 kg of carbon (about 3 tons of CO_2); a TOE (ton of oil equivalent) of gas releases some 600 kg of carbon and a TOE of coal releases approximately a ton of carbon. This means that each year, several billion tons of carbon are emitted and “stored” in our atmosphere and oceans.

It is estimated that there are 760 billion tons of carbon floating around in the atmosphere. The quantity of carbon contained in proven reserves of fossil fuels is estimated at 500 billion tons, with a potential further 3300 billion tons of additional resources.
The problem is that there is very little chance (based on our current knowledge) that we can multiply the amount of carbon contained in our atmosphere by a rate of 4 or 5 without having a major effect on our climate.

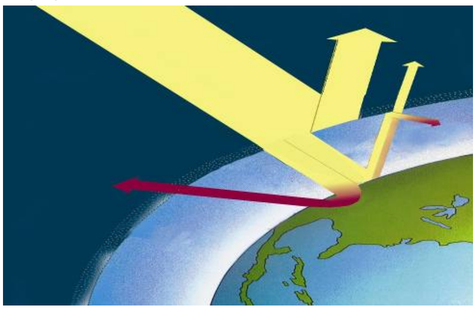
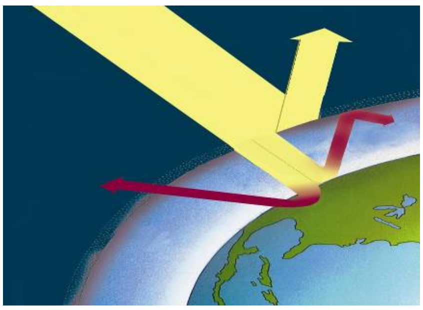


Illustration of the natural greenhouse effect.



The greenhouse effect boosted by human activity (illustration)

We have now established that there is a link between the level of carbon in the atmosphere and climate warming.
The correlation between emissions of CO_2 and disruptions to our climate is taken very seriously by the various international climate authorities (particularly the IPCC [Intergovernmental Panel on Climate Change] and the WMO [World Meteorological Organisation]).

Over the course of a century, the climate has warmed up by 0.5°C. This increase in temperature is thought to be a significant factor in the increase in the greenhouse effect by the IPCC scientists commissioned by the United Nations. In addition, climate models all show, despite their various differences, that if we continue at our current rate, the climate is likely to heat up by anything from 1.4 to 5.8°C between now and 2100. That may not seem like very much, but we need to realise that during the great ice ages of the Quaternary period, the Earth's surface was only 5º or 6º lower than it is today, which was sufficient for glaciers to cover the whole of northern Europe and for sea levels to be 120 metres lower than they are today. Going in the other direction, the temperature during the time of the last dinosaurs, 80 million years ago, was only 5ºC warmer than it is currently. It was all that was needed to have forests growing instead of having ice caps.

Consequently, an apparently minor change in temperature can have a major influence on sea levels, rainfall and the ecosystems themselves. But more than its extent, it is the speed of this possible variation in temperature that has scientists worried. In fact, the forecast rate of change is several dozen times faster than anything the Earth has experienced until now. Hence, concerns about the ability of farming and forestry systems being able to cope with this brutal change. A rise in sea levels of 50 cm to 1 metre would have serious consequences for many people who live in very low-lying coastal areas (Bangladesh, Nile delta, etc.). Some populations living on low islands in the Pacific (such as Tuvalu) will be forced to evacuate entirely within the next 20 years and are already negotiating to move elsewhere…

Scientists also raise the probability of the migration of tropical disease zones (with viruses moving in parallel with the movement of climate areas).

Breakdown of resources, dependencies

The various forms of primary energy are not distributed evenly across the globe. Some countries depend on other nations for their supplies of energy. This fact involves economic exchanges and can play a major role in relations between states.

For the most part, these reserves are located outside high consumption areas. This dependency of the industrialised countries on energy exporters can lead to serious crises that are capable of threatening the world's fragile socio-economic balance (oil crises of the 1970s, the Gulf Wars, etc.).

Crude oil reserves in 2000, in millions of tons. Source: BP 2001		
Europe	2,500	2%
North America	8,500	6%
South America	13,600	9%
Asia, excluding Russia	9,000	7%
Middle East	92,500	65%
Africa	10,000	7%
Asia-Pacific	6,000	4%
World total	**142,100**	**100%**

My energy and other people's energy: unevenness of consumption

The consumption of energy in the world varies greatly from one region to another.
The average American consumes 8 tons of oil a year, compared with 0.3 tons for the people in some African and Asian countries.
It is estimated that two billion of the people on Earth are living without electricity.
On average, those people in Africa who are connected to the electricity grid use 150 times less power than a single Canadian.

In the West, a rate of 500 to 600 cars for every 1000 inhabitants is common. In China and India, this rate is (still) of 2 cars for every 1000 inhabitants, although it is rapidly rising.

Today, the world's seven most industrialised nations gobble up almost 50% of the planet's energy resources. Questions might well be asked about the choice of this development model for the remainder of the international community.

Energy and risks

Risks associated with the technologies used

Unfortunately, the history of mankind seeking to put the forces of nature to work for its own purposes is full of disasters and accidents of all kinds. Whenever energy is converted from one form to another, it involves a risk for humans and/or the environment. After World War Two, the use of atomic energy for civilian purposes took these risks from a local to a continental level. And as for our use of crude oil, gas and coal, we are talking about the climate changes brought about as a result on a planetary scale.

Risks associated with the transport of energy

To be able to use primary energy, we usually have to go and collect it, transport it somewhere else, convert it and/or store it. This, of course, requires energy in itself. It also places a burden on the environment and generates risks (accidents, oil slicks, etc.).

More than shipwrecks and giant oil tanker colliding, it is the practice of tankers cleaning their holds at sea ("degassing") that is to blame for the consistent pollution levels on the major commercial oil-carrying routes. This practice alone represents almost 1.5 million tons of oil discharged into our oceans each year. Add to that the additional 1.5 million tons from drilling at sea, or industrial plants whose discharges of hydrocarbons travel down rivers and into the sea.

Growth in consumption

While in pre-industrial European societies where people were essentially farmers and traders, man had the energy equivalent of the work of eight slaves, this potential today is something in the order of a hundred and fifty to two hundred slaves in the industrialised countries of Europe and North America.

Since the end of World War Two, energy consumption in so-called developed societies has multiplied by four. Today, the average European consumes thirty times the energy needed for his or her physiological needs.

Energy efficiency on a daily basis

Reading the paragraphs above is enough to send a chill down your spine…
However, each one of us can take action to ensure that things do not become any worse. Better still, each one of use can contribute on a daily basis to improving the quality of life, today and into the future.
This can be done in a myriad of small, everyday ways that will often increase the well-being of the people who use them, as well as the people around them.

Our aim here is to present an approach that can be used every day to track down and do away with energy wastage. The four questions that every energy detective should be asking are:

1. What are my needs? Should I be re-examining them?

Do I have the heating set at 19º or 23ºC? Do I take my holiday in the antipodes or in my local area? Do I eat products that are in season or opt for frozen food? What services do I need? Are these needs legitimate/rational? Is there any way of reducing them? These are difficult questions, even disturbing ones. Are we able to live better by consuming less?

2. Can I get plugged into natural energy?

Does the natural environment meet my needs directly?
It is very easy to see when too much energy is coming into our living environment and we can place filters in the way to protect ourselves from it (such as blinds when there is too much sunshine). On the other hand, when we feel there is a lack of energy (shade, cold), we usually tend to call on some form

of technology (light bulbs, radiators) before we remove the filters that are cutting us off from the natural – free – and non-polluting sources of energy (daylight, putting on a sweater), etc.

3. Am I using effective appliances?

Is the technology I am using consuming non-renewable forms of energy? This is an important question when we are making a buying decision (fluorescent light – with an energy-saver tube – instead of halogen). We also need to ask ourselves the same question in our everyday lives: do we take public transport or use our own vehicle?

4. What about losses?

Is there some sort of obstacle (a loss) between the supply of energy and the need for it (such as an open window above a hot radiator)?

The four levels of our own intervention in the four areas of daily energy usage can be listed as follows:

- Residential heat: heating where we live, hot sanitary water, cooking.
- Private travel: individual vehicles.
- Household appliances in the home: lighting, cooling, laundry and dishwashing appliances, office software and other.
- Indirect “hidden” consumption: production of consumer goods and services (food industry, packaging, water, travel, sport, commerce, etc.); public consumption (education, health, armed forces, government administration, etc.); production of indirect consumer goods and services (heavy industry, manufacture of machines and equipment, etc.).

Teaching note

The concept of energy is a difficult one to put together, all the more so because it is often incorrectly used in common expressions or daily living. To explain the word “energy”. primary school pupils think of the body’s energy (“I feel full of energy this morning’”), as well as naturally occurring phenomena (bolts of lightning, the sun), supernatural phenomena (firing destructive rays), and, for the older children, electrical and nuclear energy. Mechanical and heat-related forms of energy are rarely thought of.

As far as electrical energy is concerned, many children think that it is produced without anything being consumed: “All you have to do is push a button!” they think. As a result, activities that demonstrate where electricity comes from are important. Other children imagine that electrical energy is like water that runs through pipes. This is not a good comparison to use, because it is contrary to the notion of an “electrical circuit” and leads youngsters to believe that electricity can be stored in some sort of tank.

Our aim is to build the foundation for the basic understanding of energy: its forms, sources and uses, as well as ways in which it is converted or can be saved. In particular, we will also deal with thermal energy – heat – which is something that children come across in their day-to-day lives.

Objectives

To be able to
- Put an experiment in place.
- Use different types of illustrations (diagrams, graphs, computer graphics, etc.).
- Look for and process information and data.
- Use a specific vocabulary.

To have experienced
- Some of the uses of energy (heat, light, movement)
- Apparatus that enables energy to be converted.

To have understood and retained
- Some of the notions linked to energy.
- The various uses for energy (heat, light, movement).
- The various sources of energy.
- Some of the ways of converting energy.
- The issues linked to the consumption and saving of energy.

Proposed activities

“Earth sciences experiments” file

- Conservation of heat
- The water cycle
- Polar climate and polar radiation
- The greenhouse effect
- Build a weather station

Research questions and working directions to be taken

<u>What is energy?</u>

Begin by asking the children what energy means for them and what the word conjures up. What phrases does the word energy appear in? The children should write down on a sheet of paper the words that relate to energy, then the results should be put together.

Then carry out an information-gathering task using books and the Internet:
- Make a list with the children of the daily uses made of various sources of energy (energy consumption): to provide heat, move about, create light, etc.

- Have them look for all of the sources of natural energy (primary energy): muscles, sun, wind, water, oil, uranium, tides, etc. What sources of energy are manufactured (petrol, electricity, etc.)? Which are renewable sources of energy and which are not?
- Embark on a book-based search for information about machines that enables the various forms of energy to be produced (heat, electricity, work, radiation): boilers, power stations, engines, lamps, etc.

The results from all this research are then presented on posters in class.

List the expressions in English that relate to energy. Ask the children to find examples in use in common everyday language containing the incorrect usage of the word 'energy'.

Do we use energy on a daily basis?

Imagine with the children what a day without electricity, heating, petrol or diesel would be like. Ask the pupils to write a small amount about what it would be like.

What are the 'pathways' of energy?

Ask the children to create posters that explain the 'pathways' of energy:
- Starting with a lit light bulb, go back through the electrical energy circuit to the nuclear or hydraulic power station.
- Starting from a radiator, go back along the thermal energy circuit to the source.
- Starting from a car driving along, go back along the energy circuit to the oil reserves.

How is electricity produced?

- Out in the school yard, demonstrate how the dynamo on a bicycle works. Back in class, work with the children to create a poster that describes the chain of energy in the dynamo, i.e. the transfer of energy (or energy conversion) from the cyclist's leg, through to the production of light: leg (muscle energy), pedalling (mechanical energy), rear wheel turning (mechanical energy), dynamo roller (mechanical energy), alternator (electrical energy), bulb (thermal energy), lighting (radiating energy).
- Give the class a challenge: how do you produce electrical current from the alternator using another source of energy? The children have to find solutions, such as fitting the alternator with a wheel with fins, then using water from the tap, or a water course or steam under pressure, etc. to drive the wheel.
- Organise a class visit to an industrial plant producing electricity: power station, dam, nuclear power station, etc.

How is energy transferred?

Suggest an experiment to the children that highlights a transfer of energy:
- Place a glass of water on a large deep plate. Take a reading of the water temperature. Cover the glass with an upside down flower pot. Pour water on to the outside of the flower pot. Place the whole experiment outside in the sun and, if necessary, pour more water on to the flower pot. When the water has evaporated, remove the pot and take a reading of the temperature of the water in the glass: it will have gone down, even though the experiment was out in the full sun.
  The evaporation of water requires energy which is taken, from among other sources, in the form of the heat of the air underneath the flower pot, hence the water in the glass cools down.

How is solar energy collected?

Set up an experiment that demonstrates the existence of solar energy:
- Make a greenhouse using an open shoe box and lining the inside with black plastic and then seal it with a sheet of glass or transparent plastic film. Place a thermometer inside and put the box in the full sun (make sure that the thermometer is protected from the direct sun by a cardboard cover). Draw a graph to show the increase in the temperature inside the greenhouse.

What impact is there on the environment?

- What are the main types of impact on the environment caused by our consumption of energy? What alternative solutions are there? In groups, have the children answer these questions by producing a small poster. The results can then be presented to the other groups to start off a debate.

<u>What steps/action can be taken in my region?</u>

- Create an exhibition that explains the path that electricity goes along from the power station to the light bulb.
- How can we save energy? After thinking up all of the small steps they could take to save energy, the class can then write a small booklet called “Instructions for Saving Electricity” that the children can hand out to their parents and friends. They could also make small posters to place in selected locations.
- Set up a “Save Energy” week: make sure the lights are switched off, save water, go to school by bike or car-sharing, improve insulation, etc.
- Create an exhibition that displays the renewable energy of the future.

Example of teaching/learning sequence

Heat and temperature

Objectives

To be able to
- Put an experiment in place.
- Ask others questions, ask oneself questions.
- Isolate variables.
- Use measuring instruments (thermometer).

To have understood and remembered
- Our body feels heat, but can be misled.
- Temperatures are measured using a thermometer.
- Thermometers are not all the same. They even use different units of measure.
- Certain substances enable heat to be retained longer.
- Time is needed to allow an object or liquid to heat up/cool down (inertia).

1. Starting point (30 minutes)

Start a discussion touching on the topic of heat in relation to time (temperature warm or cold for the season, switching on the heating system at school, press articles, etc.).

2. Collecting illustrations (45 minutes)

<u>The child’s perception</u>

What does the word ‘heat’ mean to you?
Does ‘heat’ mean the same thing as the word ‘temperature’?
Start a discussion, then have each child explain on paper what heat and temperature mean for him/her.

3. Putting a research method in place (45 minutes)

How do we evaluate whether an object or liquid is hot or cold?

First of all by visual indicators: the “cloud” rising from a hot coffee, ice crystals on a frozen product. Have the children draw all of the indicators that they know: is it something hot or cold being shown and how?

Then through our body: our skin has nerve endings that enable us to detect differences in temperature. That way, the body can tell us whether something is hot or cold.
Hand out the “How do we feel heat?” sheet to the children and carry out the activity.

4. Instrumental phase (45 minutes)

The indications and sensations left by contact are subjective means of evaluating whether an object is hot or cold. By contrast, temperature is something physical that characterises these sensations in an objective manner.
A thermometer is an instrument that enables us to measure temperature accurately.

Hand out the "Measuring temperature" sheet to the children and carry out the activity.

To measure a temperature, there needs to be a point of reference. In the Celsius system, the scientist (Anders Celsius) opted to have the temperature at which pure water freezes to determine zero degrees, and the boiling point for water at normal atmospheric pressure at sea level (1 atmosphere or 1.013 bar) as 100 degrees. There are also other ways of measuring temperature, such as degrees Kelvin (273°K = 0°C) and degrees Fahrenheit. In class, investigate how these other temperature scales are structured. Place the children in a situation that enables them to find new points of reference for measuring temperature.

5. Experimental phase (90 minutes)

How do we increase the temperature of an object or liquid? A certain amount of energy has to be applied to it in the form of heat. We then come across a new meaning of the word "heat", i.e. thermal energy.

Hand out the "How to heat water" sheet to the children and carry out the activity.

6. Questioning findings (45 minutes)

There will certainly be different types of flooring at school: tiles, parquet, synthetic floor covering, etc. Create a circuit taking in several different floorings that the children can walk round in bare feet.
Then rank the flooring types from the warmest to the coldest. Tiles will appear to be noticeably colder.
Then do the same circuit again with an electronic thermometer to measure the temperature of the floor types: all of the flooring types will be virtually the same temperature! So our body is able to deceive us in terms of feeling hot and cold.

You can carry out the same type of experiment by touching the same object with different parts of the hand: try the steel feet of a table and its plastic or wooden surface; or the rubber grips on the handlebars of a bicycle and its steel frame, etc.
Each time, the child will think the temperatures are different, whereas the thermometer will say the contrary.

Start up a discussion in class to explain this mystery of the thermal conductivity of different substances.
When a material is a good conductor, it takes heat from the skin and gives the body the impression of cold. That's why tiles appear to be cold.
On the other hand, other materials are poor conductors of heat. They are insulators and do not take any heat from the skin, leaving the impression of being more or less of the same temperature as the body.

Hand out various materials in class and have the children classify them according to their thermal – and also electrical – conductivity.

7. Evaluation - assessment (45 minutes)

Have the children create a scientific poster dealing with what they have learnt about heat and temperature.

Work sheet for pupils

First names of the pupils in the group:

……………………………………………

……………………………………………

How do we feel "heat"?

Idea for the experiment: you go and "touch" water in different ways and at various temperatures to say what you feel, and then rank them from the coldest to the warmest.

For each of these experiments, it is important that each person in the group be able to carry out what is required.
Then make a note of your comments.

Experiment 1

Immerse your left hand in bowl 1 and your right hand in bowl 3 for 30 seconds:

Cold water   Lukewarm water   Hot water

After 30 seconds, immerse both hands in bowl 2 (Lukewarm water).
What do you feel? Do both hands feel the same "heat"? Why?

Results and observations from the experiment:

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Experiment 2

Immerse various parts of the body (different fingers, hand, wrist, forearm, foot, etc.) in a bowl of cold water.

What do you feel? Do all parts of the body feel the same "heat"? Why?

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Results and observations from the experiment:

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Experiment 3

a b c d e

Ranking 1:

Touching the outside of the bowls only, rank them in order **from the coldest to the hottest**, giving one word to define the water for each of them.

Order:					
Word:					

Ranking 2:

Immersing your fingers in the bowls, rank them in order **from the coldest to the hottest**, giving one word to define the water in each of them (cold, lukewarm, etc.)

Order:					
Word:					

What do you notice? Which ranking was the easier to carry out?

Results and observations from the experiment:

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

…………………………………………………………

…………………………………………………………

……..

First names of the pupils in the group:

…………………………………………………

…………………………………………………

Measuring temperatures

- How is the scale of degrees structured?
- What represents 0 degrees and what represents 100 degrees?
- What do other temperatures represent in your environment?

To be able to answer these questions, take the temperature of the air or water in different locations around you, using a thermometer.

- **Note down your readings on the drawing of a thermometer (next page) using an arrow and words indicating the location where the reading was taken.**

Observations:

The temperature scale (for our system: Celsius) is structured according to

…….

The main markers are:

0° (degrees) = ………..……………………………………………………………………………………

…….

100° (degrees) = …………………………………………………………………………………………

…….

Experiment 1:

- Fill a flask **with very hot water** from the tap.
- Use the felt pen to mark the level of water on the flask.

Allow your flask to rest in the open air or immerse it in cold water. Observe the flask.

What happens? ……………………………………………………………………………………………..

Why do you think that happens?

Observation: …………………………………………………………………………………………………

………..…

Experiment 2:

- Empty your first flask.
- Fill the flask **with cold water** from the tap. You can add a blue dye so that you can see the level of the water better.
- Use the felt pen to mark the level of the water on the flask.

Well done: you have made a thermometer!
Place your thermometer in various hot or cold places to see how it reacts.

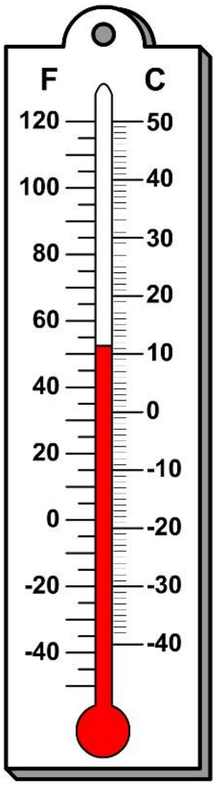
Observations:

If the thermometer is in a colder environment, the level of the water

………………………………………………………. ;

If the thermometer is in a warmer environment, the level of the water

………………………………………………………. .



Work sheets for pupils

How do we heat water?

First names of the pupils in the group:
………………………………………………
………………………………………………

Idea for the experiment: you are going to heat the water contained in a can.

Challenge 1:

What is the maximum temperature water can be heated to in a can using tea lights (small candles)?

Instructions:

1) Guess what the maximum temperature is that can be reached and write it down: …………………………

2) Explain why you have chosen this temperature:

………
………
………

3) Check your answer using the following equipment:

- Cans
- Candle(s)
- Support board
- Backing strip
- Matches
- Water thermometer

IMPORTANT: Do not move the can and call the teacher if you need to!

BE CAREFUL, the thermometer is **FRAGILE**!
- Place it on the table so that it does not fall.
- When taking temperatures, hold the thermometer so that it does not touch the bottom of the can.

4) Make a drawing of your experiment and explain what you have done:

………
………
………

Results: …………………………………………………………………………………………………

5) Compare your results with Question 1 and note down your comments:

………
………

How do we heat water?

Idea for the experiment: you are going to heat the water contained in a can.

<u>Challenge 2:</u>

Variant for older students:

What is the maximum temperature water can be heated to in a can using tea lights (small candles) and in the shortest possible time?

<u>Instructions:</u>

1) Guess the maximum temperature that can be achieved and write it down: ____________
2) Explain why you chose this temperature:

……………………………………………………………………………………………………..………………..

……………………………………………………………………………………………………..………………..

……………………………………………………………………………………………………..………………..

5) Check your answer using the following equipment:

- Cans
- Candle(s)
- Support board
- Backing strip
- Matches
- Water thermometer

IMPORTANT: Do not move the can and call the teacher if you need to!

BE CAREFUL, the thermometer is **FRAGILE**!
- Place it on the table so that it does not fall.
- When taking temperatures, hold the thermometer so that it does not touch the bottom of the can.

4) Note your results in the table below, then make a drawing of your experiment:

Temperatures											
Minutes											

Results: ……………………………………………………………………………………………..……………………

4) Compare your results with the question and note down your comments:

……………………………………………………………………………………………………..………………..

……………………………………………………………………………………………………..………………..

……………………………………………………………………………………………………..………………..