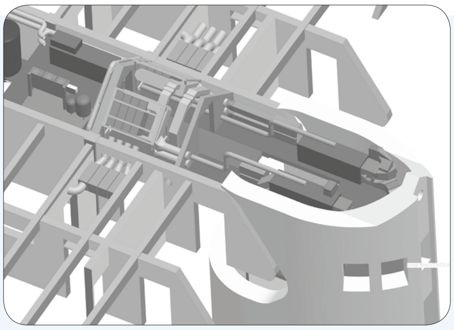
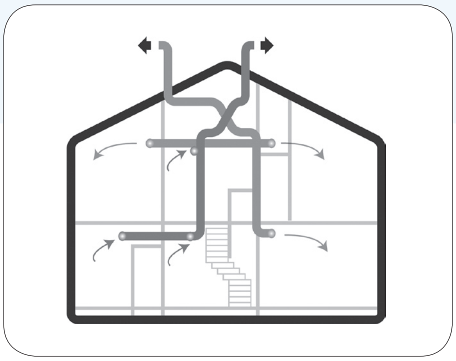
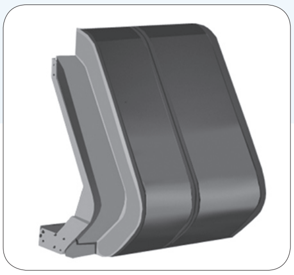
○ History ○ Languages ○ Geography ● Sciences ● Technical Education

The **technical side** of the Princess Elisabeth station







INTERNATIONAL
POLAR FOUNDATION

TABLE OF CONTENTS

THEORETICAL NOTE

The station site is set and both the interior and exterior walls of the station have been put in position (see pedagogical dossier 'BELARE: the station was not built in a day!'). To turn this station into a 'zero emission' station, the right technologies have to be selected. First all kinds of energy simulations are carried out to find out which systems require the least amount of energy. Based on these studies, the most optimal systems are selected.

But which are the most optimal systems? Can these also be used in your house? Will the Princess Elisabeth Antarctica (PEA) station become a 'passive house'? Get to know more about the different aspects of this energy topic and discover the renewable aspects of the station.

INTRODUCTION

A passive house can be defined as a building with minimal energy requirements where a pleasant interior climate is created without using conventional heating or cooling systems during both winter and summer. The gross consumption limit for heating the interior of the station is 15 kWh/m² year, while the energy consumption for heating (hot water, heating, household equipment) cannot exceed 42 kWh/m² year. Four aspects need to be taken into account: good insulation of the windows and the walls, ventilation, air density and orientation. Another advantage is the use of renewable energy. The great diversity of technologies, designs and materials marks a new era of energy-efficient possibilities.

But what about all the different passive house aspects? Are they being applied to the station?

The complete energy concept for the Belgian polar station was tested and designed before any construction began. Studies and energy simulations showed that the total energy demand for the four summer months during which the station will be manned will be around 7000 kWh/month, whereas for the eight winter months around 2000 kWh/month. With a total surface area of around 1500 m², the station will consume 54 MWh of electricity per year. This translates into an average annual use of around 51kWh/m² year.

In order to be able to comply with this energy demand, the station designers choose a **hybrid system** for the PRODUCTION of energy in which the different energy sources, namely solar and wind energy, are used simultaneously. This allows the system to be very flexible when it comes to adjusting to different weather conditions. When there is not much wind, the solar energy can be used and when there is not much sun, wind energy can be used. This means optimal use of the free and natural energy sources available.

WIND TURBINES

The earth does not receive the same amount of energy in every part of the planet. Differences in solar energy received leads to differences in temperatures. This leads to large-scale atmospheric pressure gradients, which in turn cause air to be displaced, creating winds. Wind turbines transform the wind's kinetic energy into mechanical energy, which is subsequently transformed into electricity.

A standard wind turbine consists of a tower, upon which the nacelle sits. In the *tower* you can find a *capstan wheel* that enables the turbine to rotate in the direction of the wind. The *nacelle* is connected to the *rotor*, which usually has 2 to 3 *blades* or vanes. At the base of each blade there is a *blade adjuster* that directs the blade in relation to the wind in order to capture a certain predetermined amount of energy from the wind. This amount of wind energy makes the rotor and the main axis situated in the nacelle rotate at a more or less constant rate. In turn the *main axis* makes the gearwheels in the gearbox rotate. Around the main axis, there are *bearings* that catch the remaining power so that the main axis is not obstructed during rotation. The *gearwheels* can be compared to the gears of a bicycle, increasing the speed of the axis and rotating the generator. The generator can be compared to the dynamo on a bicycle, converting the mechanical energy generated by the revolving axis into electricity. The voltage of this generated electricity is subsequently converted by a *transformer*. There is a *brake* between the *gearbox* and the *generator* to stop the turbine if the wind turbine should ever require maintenance. On top of the nacelle there is an **anemometer**[1] and several *sensors* to measure the strength of the wind and to regulate the turbine's rotation speed during storms. This sensitive equipment is connected to a computer-operated control box, which starts the wind turbine at a certain wind velocity and stops it when the wind is too strong.

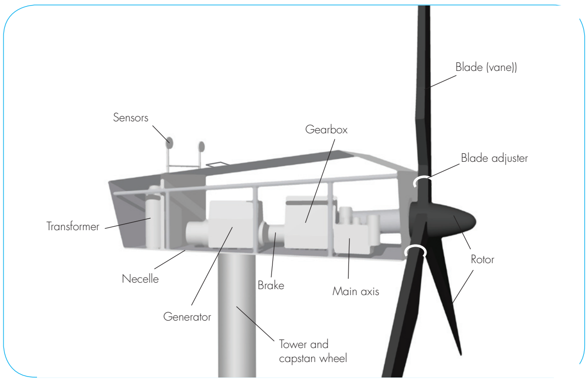


Figure 1: The different components of a wind turbine

There are different kinds of wind turbines, subdivided according to their size, their capacity, the orientation of the axis (horizontal or vertical axis), their location (land or sea), etc. The amount of energy generated heavily depends not only on the altitude of the rotor and the rotor surface, but also on the location, time of day, season, the distance between the two turbines, wind availability and the wind velocity.

Eight wind turbines are installed north of the Princess Elisabeth station, solidly designed to withstand the tough weather conditions of Antarctica. Six of the eight wind turbines are operational all year long. The other two serve as backup turbines and will only be used in case the other wind turbines malfunction and need maintenance.

Contrary to the standard model described above, the PEA wind turbines have the following characteristics:
- no gearwheel transfer but a **self-regulating rotor**[2] with three blades made from flexible thermoplastic **composite**[3] material (rotor diameter: 5.5 m), directly connected to the generator, which minimizes energy loss. The amount of power generated is directly dependent on rotation speed.
- a capacity of 6 kW and an altitude of 9 m
- no sensors or anemometer; the measured data are delivered by the automatic weather station (AWS) (see also pedagogical dossier 'BELARE: the station was not built in a day!')

Usually wind turbines stop automatically when the wind is too powerful. This is not the case on the Utsteinen ridge. The pioneering innovation is the combined mechanism which generates the maximum amount of power from light winds and reduces the amount generated from heavy storms. The mechanism works as follows:

1. winds that are too strong transform the blades of the rotor, reducing the efficiency of the rotor; due to the change in shape, the rotor will slow, converting less wind into rotational energy.

2. in addition, the blades can be 'folded together' according to a predetermined angle by means of a control triangle. When there are light winds, the angle of the blades in relation to the horizontal plane is approximately 5°; when there is a storm the angle of the blades can go as high as 45°, which equals a halving of the rotor diameter. This has an immediate effect on the rotational speed.

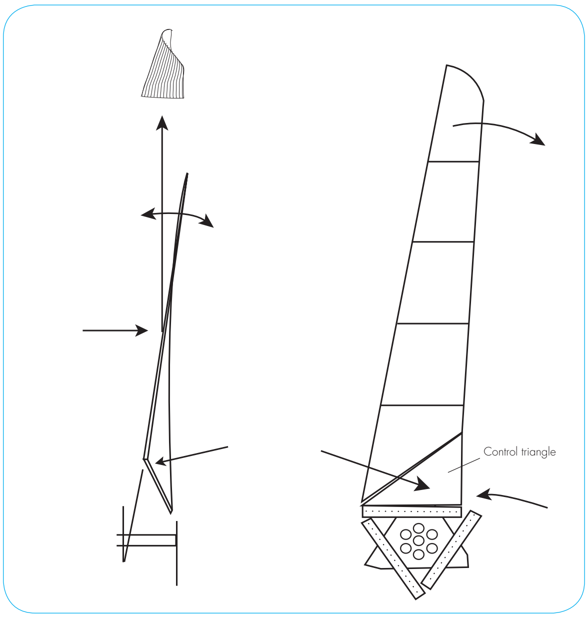


Figure 2: A blade of a PEA wind turbines © ProvenEnergy

PHOTOVOLTAIC SOLAR PANELS

As the term suggests, photovoltaic (PV) solar panels make use of solar energy. One component of solar energy, photons, are utilised. Photons are high energy particles that move in waves. They have a

1 An anemometer is a wind-gauge; it measures the wind velocity.
2 Normally, the turbine is automatically shut down when the wind velocity is too high. This is done by means of a **self-regulating rotor,** which ensures that the wind turbine will only be slowed down.
3 **Composites** are compound synthetic materials.

wavelength which is dependent on the amount of energy they contain. The light we see consists of photons. The photon will either be reflected by, go straight through or be absorbed by the solar cell, depending on its wavelength. Only the absorbed photons can produce electricity.

A photovoltaic solar panel is a collection of PV solar cells which together transform the solar energy into electricity. The standard solar cell consists of different layers. The upper glass layer is in direct contact with the outside air and serves as a cover layer. Underneath is an anti-reflection layer. A metal contact layer forms an external electrical circuit together with a similar layer underneath the cell.

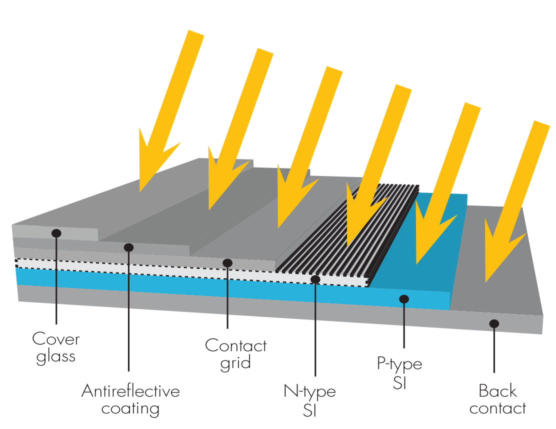


Figure 3: The different layers of a solar cell

Between the metal layers in a photovoltaic cell there are two layers of silicon (Si). Pure silicon is not suitable. When a silicon atom is hit by photons from the sun, it knocks electrons in the atom loose, allowing them to move freely. However with no electron gradient between the layers, the electrons don't have any impetus to move in a particular direction and create electrical current. Therefore each of the two layers of silicon is doped with two different substances - one with more electrons than silicon, such as phosphorous, and one with fewer, such as boron - creating a diode. Having one layer of silicon with more electrons and the other layer with fewer encourages the electrons in silicon atoms knocked loose by the sun to flow from one layer to the other, forcing the electrons to stream in one direction and creating an electrical current.

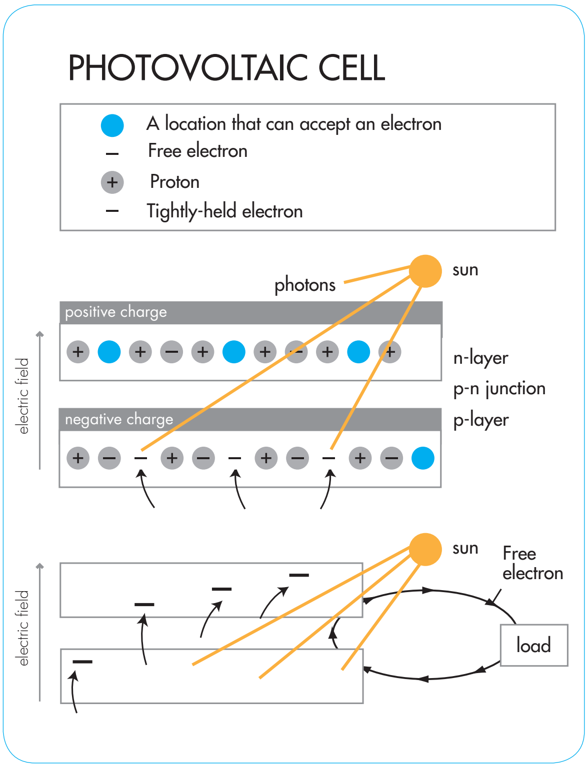


Figure 4: A diode based on silicon

The solar cells differ in terms of thickness, colour and general characteristics depending on the equipment and technology that is used. The technologies are updated regularly, each time optimising efficiency and cost. However it is important to keep in mind that the amount of energy produced from a solar cell is strongly dependent on the wavelength of the incident light and the climate conditions. The more clouds present in the sky, the smaller the amount of electricity generated.

The Princess Elisabeth station makes use of 408 solar photovoltaic panels: 109.5 m² or 120 PV solar panels on the walls of the station, pointed in all directions to make optimal use of solar energy and 270 m² or 288 free modules on the garages pointed towards the north, making a total production of 50.6 kWh (up to 800 W/m² sunshine). Every panel has an efficiency of 16%, a nominal yield of 12 V (max. ~17 V) and consists of 36 silicon solar cells with a standard size of 150 mm by 155 mm. Different solar panels are connected in series or in parallel to others in order to form a complete solar park to supply the station with electricity.

Figure 5: The PEA photovoltaic solar panels © Kyocera

In order to withstand the extreme weather conditions in Antarctica, these solar photovoltaic cells are protected by reinforced glass on the one side and a special foil on the other. Everything is hermetically sealed. Everything is encased in a solid aluminium frame, which is easily installed on the station or the garages. The cold temperatures ensure that the solar cells do not get overheated.

THERMAL SOLAR PANELS AND BOILERS

Solar energy can also be used for generating heat. This can happen both passively and actively. For example, passive thermal solar energy heats up a room directly with the incidence of solar rays. The system of thermal solar panels and boilers is an example of active usage of solar energy. A solar panel or a solar collector is placed on the roof. This is usually a black plate made from good conducting and heat-absorbing material such as metal. A heat-transporting liquid circulates within this plate. The solar heat is absorbed by the solar collector and subsequently transferred to the liquid inside, which is sent via a pumping system to a boiler filled with cold tap water. The heated liquid from the solar panel transfers its heat to the cold tap water in the boiler via a heat exchanger, after which it returns to the solar collector to be reheated. The heated tap water can then be used to take a shower, wash dishes, etc. When there is a shortage of sunshine in the winter, after-heating can be performed by a Central Heating boiler to ensure that there is enough hot water.

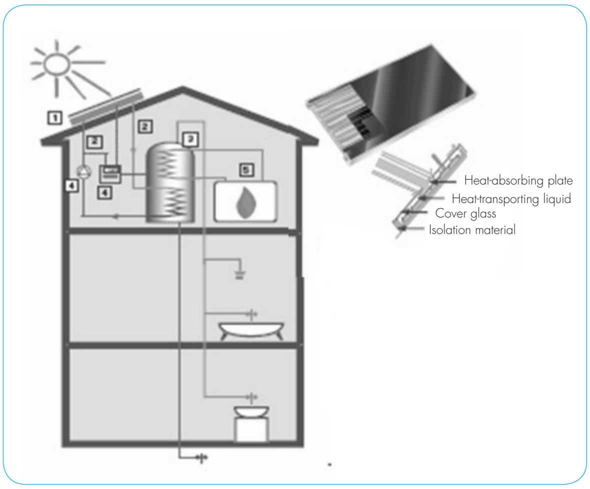


Figure 6: The system of solar panels and boilers

There are many different types of solar collectors; however they all have same end result of heated water. A vacuum collector for example is not that different from a flat plate collector. Both consist of a material that absorbs solar radiation, a stream of liquid, a cover plate and insulation. They differ in the way they are insulated. A plate collector is insulated with glass wool, while a vacuum collector is insulated by vacuum, just like in a thermos. The better the solar radiation can be absorbed, the more intense the heating becomes. This depends on:
- the conductibility of the material,
- the colour of the material (black absorbs better than white),
- the reflectivity of the material (a mat surface does not reflect as well as a shiny one) and
- the specific heat capacity (= the capacity to store heat) of the absorbing material.

The PEA station uses both active and passive solar energy.
The size and the direction of the windows with respect to the sun were thought out very carefully. In contrast with a passive house in the temperate regions of the planet, the largest window surface is not on the sunny side. During the summer there is a lot of sunlight, sometimes even for 24 hours! Combined with the strong insulation this would lead to overheating of the interior. The largest windows of the station are therefore put on the southern side (this is analogous to the northern side in the northern hemisphere!). What also prevents overheating is the placing of the windows waist-high. Since scientists spend most of

their time sitting down, they can enjoy the view on the vast snow plains.
The heating of the interior spaces is complemented by the heat given off by electrical equipment and human activity.

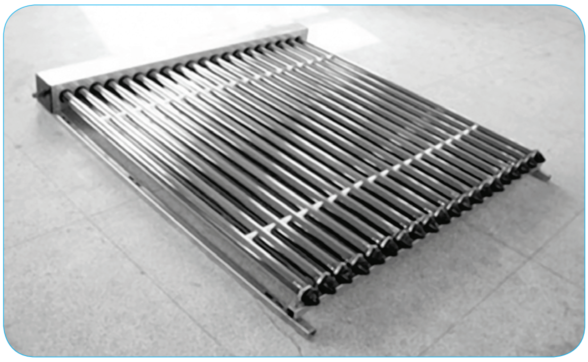


Figure 7: Vacuum collector

The heating of water by means of solar energy is an example of active usage of solar energy. There are two groups of thermal solar panels (vacuum collectors). One group of solar panels is situated on the roof of the garages (6 m²) and is connected to the snow melter. The melted water is subsequently stored in a reservoir in the technical core of the station. There it is stored along with water from a tank in which recycled water is stored. A second group of solar thermal panels is integrated on 19 m² of the station's roof. Both the melted and the recycled water are heated to a pleasant temperature and subsequently they are sent to the bathroom, kitchen and washing machines through a distribution network. The thermal solar panels are pointed towards the north to make optimal use of the sunshine. All the solar panels on the base are mounted directly on the walls to ensure there is no space between the panel and the walls of the station. This prevents accumulation of drifting snow. Electrical reheating of the water is provided in case they cannot produce enough hot water.

BACKUP DIESEL GENERATORS & BATTERIES

The backup diesel generators can be compared to the emergency generators in a hospital. Two of them have been placed in the northern part of the so-called 'dirty' part of the garage (see pedagogical dossier 'The Station: from the inside out!'). They each can generate 44 kWh.

When there is an energy shortage, certain systems will get priority over others based on a predetermined list. In this respect, systems linked to **human safety** such as fire protection systems, water production and ventilation will get the highest priority, followed by **other regulation systems** such as the system that regulates temperature and humidity, the closing of the doors, etc. A tertiary level of priority is given to **maintaining scientific samples** and guaranteeing that scientific data does not get lost. If, for example, there is not enough sun and wind at a certain time and a crew member wants to connect his laptop to the network, the system will signal that other systems, such as the snow melter, have priority over the functioning of a laptop.


Figure 8: From high priority to low priority: fire safety, water melter, temperature regulations, dishwashing machine, television,…

The primary objective is to use the generated electricity from the network **immediatly** and only in case of an energy surplus, to STORE the generated energy in batteries. There are two reasons for this:
1) when stocking energy in batteries there is always some energy loss;
2) the charging and discharging of the batteries affects their efficiency and therefore also their lifespan, so they will have to be replaced more often. Knowing that the batteries by themselves weigh 12 to 15 tonnes, it is not recommended to overburden them when it is not necessary.

In the technical core of the station (see pedagogical dossier 'The Station: from the inside out!') there are two clusters of **gel batteries**[4], which together have a total capacity of 6000 Ah. In case these batteries are fully charged, the surplus of energy is evacuated by means of dump loads. If the surplus of energy is NOT used, it could cause damage to the electrical systems. The dump loads convert the surplus of energy during the winter months into heat for the technical core and the living quarters. The technical core is thermally insulated all around by plates just before the start of this severe weather season. The energy surplus can also be used during the winter for electric radiators. During the summer, the energy surplus is transferred to systems that can use the energy more efficiently, such as the little huts outside the station where the measuring equipment is located or the snow melters for the production of potable water.

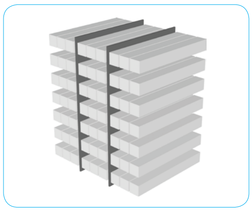


Figure 9: The gel batteries

4 A gel battery is a modified design of the standard lead battery for cars or ships

All year long, each of the stations' systems can be checked and adjusted from Belgium at any moment of the day.

In order to reduce the energy CONSUMPTION to the bare minimum, household equipment was selected on the basis of its energy efficiency, such as A++ refrigerators and freezers, induction hobs, low-energy light bulbs, etc.

VENTILATION AND HEAT EXCHANGERS

Good ventilation is necessary for human comfort and to avoid condensation. In a traditional house this can be achieved by natural ventilation (opening windows), ventilation by sucking in fresh air or ventilation by diversion of internal air. These classic ventilation methods channel the air between different spaces. Fresh air is sucked into 'dry' spaces (living room, bedrooms, etc.) and 'polluted' air from the so-called 'moist' spaces (kitchen, bathroom, etc.) is removed. Because there is a pressure gradient between dry and moist spaces (dry spaces are under higher pressure while moist spaces are under lower pressure), a continuous flow of air is guaranteed. This can only happen when there are different 'transfer openings' between these spaces in the doors or walls.

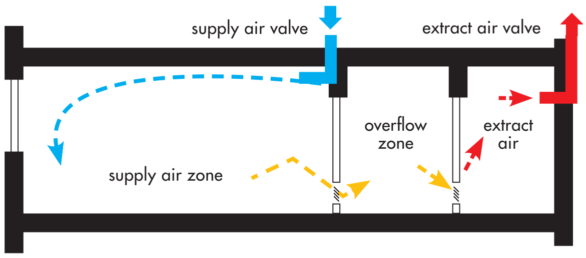


Figure 10: Ventilation flow

In a passive house only one ventilation system is used. This is done by means of mechanical supply and removal of air ('double flux'). A heat exchanger is necessary when trying to recycle heat to reduce energy costs. By exchanging heat between the removed heat and imported cold air, 75 to 95% of the energy can be recycled. Both flows of air are not in direct contact with each other, but cross one another in a counter-current heat exchanger.

One example of this is the earth heat exchanger, in which the sucked-in air first needs to flow through tubes 1.5 m under the ground before it is released into the living quarters. In temperate regions in the summer the ground is always cooler than the air. Thus outside air at 30 °C cools to 22°C after passing through the tube system of an earth heat exchanger. In the winter however, the ground is warmer than the air, so the incoming air will heat up before it is released into the passive house.

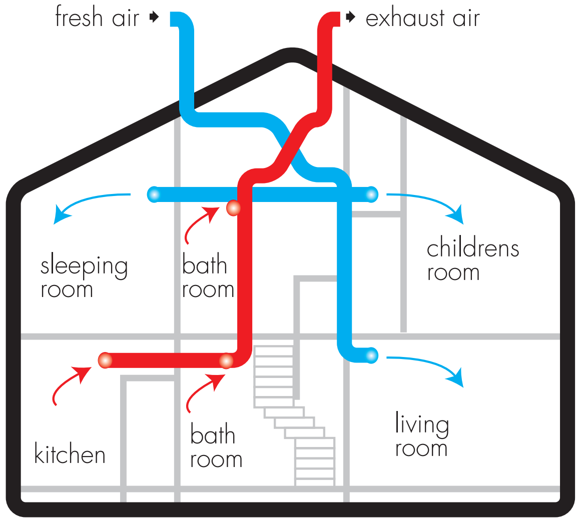


Figure 11: Ventilation system in a passive house

The heat is spread through the entire house and thus a pleasant interior climate is created. It does not need to be said that the whole tube system needs to be insulated very well and that the hinges need to be made airtight, so that there is no loss of air and energy.

But what if the incoming air is hotter than the outgoing air? In this case, the recycling of heat will indeed not be necessary and the incoming air can directly be injected through a 'bridge' into the different spaces.

The ventilation systems of the station are comparable to those found in an average passive house. Three separate ventilation systems provide the station with fresh air and remove stale air. Two in the living quarters (living room, office spaces, etc.), which are only operational during the summer season, and one completely dedicated to the technical core, which is operational all year long.

Each separate system has its own network of tubes, in which the incoming air is first heated by means of a counter current heat exchanger and then humidified by an electric humidifier to a humidity level of at least 15%. This serves to not only provide a pleasant living environment for people in the station, but also create a suitable environment for the equipment as humidified air can help prevent static build-up and electrical discharges. In case one ventilation system breaks down, the others can take over its job.

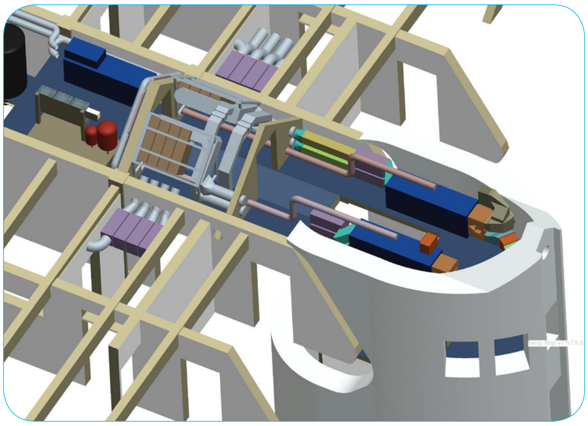


Figure 12: The three ventilation groups (in blue) in the PEA base.

WASTEWATER TREATMENT SYSTEM

Water on earth is purified in a natural way every day. Organic waste is decomposed by microorganisms in river water. When there is too much wastewater in the waterways, the biological balance can be disturbed and the natural self-cleansing process jeopardised. In order to prevent this, organic and chemical waste must be removed from the wastewater before they are discharged.

The simplest way to purify wastewater is by using microorganisms to decompose the organic matter while the non-decomposable components such as heavy metals can be removed from the water via chemical treatments. Usually two processes occur. The first is *coagulation*, the process by which colloidal or floating particles are neutralised using a chemical substance, the coagulant. The colloidal particles are smaller than 1 micron, negatively charged and stable in water. The coagulant, which usually is a metal ion, is positively charged and thus neutralises the negative charge of the colloidal particle. This way the particles will not repel each other any longer and due to Van Der Waal Forces will attract each other and form clots (*flocculation*). Subsequently, these clots can be filtered out of the water.

Nowadays, big wastewater purification plants with various purification phases are being built. The *primary purification* consists of a physicochemical treatment, which removes most of the floating elements such as oils and fats from the water. This way, the water is prepared for the next phase: *biological purification*. During this second purification, the organic pollutants that are dissolved in the water are removed. Two major technologies are applied for this purification:

1. Aerobic biological purification: microorganisms break down organic components in a well-aerated environment.
2. Anaerobic biological purification: microorganisms break down organic components in the absence of oxygen.

The objective of a *tertiary purification* is recovering the product. In this phase, absorption, fine filtration and concentration can be applied in order to separate particles from all kinds of liquids.
Eventually, the liquids can be disinfected by using ozone (O_3), UV, etc., which each have their own advantages and disadvantages.
Depending on the circumstances and the objectives, a specific water purification plant, specific purification means and technologies, and specific disinfection techniques will be chosen.

The Belgian scientists on Antarctica will be the first on the great white continent to recycle up to 75% of their wastewater for secondary use. This technique is already used in space travel. After treatment, the unusable water is purified and discarded in a crevice between the ice and the rocks.

Gravity causes the wastewater to fall in two collecting vessels, which are located in a technical area at the base of the tower.

- The upper vessel collects the blackest and most polluted water coming from the toilets and the kitchen. This tank contains an internal draining pump that further fragments the particles and pumps them, against gravity, to the anaerobic bioreactor in the technical core.
- The bottom tank collects the grey or slightly polluted water coming from the showers, the washing machine and the dishwasher. This tank is connected to an external pump in order to pump the now particle-free liquid, to the aerobic bioreactor.

The anaerobic digestion of the black water takes place in the anaerobic bioreactor under high pressure, low pH (in order to prevent the formation of methane) and at 55 °C. This temperature is reached with the help of a heating mantle at around 70 °C, which is attached to the already well-insulated tank. This mantle contains water heated by thermal solar panels. This bioreactor is connected to a filter. This way, the anaerobic sludge is continuously pumped out of the bioreactor through the filter, after which it returns to the bioreactor. The filter collects all insoluble elements from the sludge and pumps the filtrate into the aerobic bioreactor where the grey wastewater also arrives. In order to get an optimal aerobic digestion, the bioreactor is kept at room temperature (25-30 °C) and oxygen is supplied to the sludge and at the base of the filter via an aeration system. This aeration promotes the decomposition of waste and the removal of nitrogen through nitrification and denitrification. The gases produced during the anaerobic

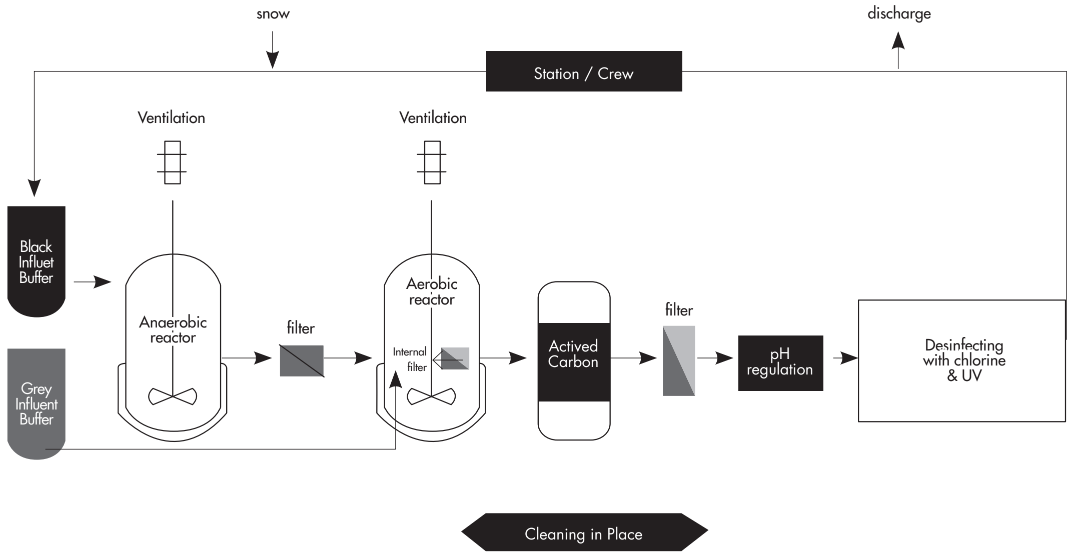


Figure 13: The water purification plant in the PEA base

and aerobic digestion are removed from the base through the station's ventilation system.

After the biological purification, the filtrate is pumped through the organic membrane of a **nanofilter**[5], after which it runs through active carbon filters. Active carbon contains small pores and follicles that can be easily filled by pollutants through a process called **adsorption**[6]. For this, the remaining waste is removed and the liquid is decoloured. At the top of the column there is a filter that removes the carbon particles and other solid substances. Before everything is stored in a tank under the roof, the acidity is regulated and if necessary modified by adding either an acidic or an alkaline substance. Finally, the recycled water is disinfected by UV exposure and chlorination before bringing it back into circulation. In these steps, the nuclei of microorganisms are modified in order to eliminate them. The remainder of insoluble waste is saved in a reservoir in the garage so it can be carried away at the end of the season.

The entire wastewater purification system is connected at different levels to a computer, which controls and regulates the temperature, pH, volume, amount of O_2, etc. In case the collection vessels become filled as well, all wastewater passes to **multiboxes**[7] in the garages. This multibox has various functions. A sick person living in the station who needs to take antibiotics will not be allowed to use the 'regular' toilets since its wastewater moves to the bioreactors. The antibiotics could destroy the microorganisms present there. For this reason, a toilet was installed in the sick bay from which the wastewater passes directly to a multibox.

In order to maximize the life span, manual maintenance is required. Each season, the active carbon needs to be replaced and the bioreactors need to be cleaned on a regular basis with water and special cleansing agents. The filters also require regular cleaning.

THERMAL INSULATION

Walls

Good thermal insulation of the walls, the roof and the windows is necessary for meeting the heat production criterion of less than 15 kWh/m² per year. The degree of insulation a substance has is expressed by its U-value. This value expresses the amount of heat that can pass from one side of a construction such as a wall to the other side per second per m² per degree of temperature difference. The average U-value of a passive house amounts to a maximum of 0.15 W/m².K.

Whether this U-value is met depends strongly on the chosen material and the thickness of the walls. A concrete wall, for instance, will need to have a thickness of 15.8 m to reach an U-value of 0.13 W/m² .K. Straw, on the other hand, is a better insulator. A straw wall of 0.41 m suffices to meet the same U-value. Of course, it is also possible to apply a mix of materials.

In an average house the thickness of the insulation layer amounts to approximately 12 to 16 cm, while the thickness of the insulation in a passive house amounts to approximately 30 cm. These measurements strongly depend on the type of insulation material as well as on the material used for building the walls.

5 A nanofilter is a filter with a porosity of 1/1000th mm
6 Adsorption is a process in which a dissolved substance is removed from the water by means of a solid substance
7 The multiboxes collect the non-recyclable wastewater coming from the aerobic bioreactor, the laboratory and the toilet in the sickbay..

The station has a wooden skeleton covered by seven layers that form a thermal boundary between the inside and the outside. This means that the cold first needs to penetrate a heavily insulated wall of about 53 cm before it reaches the inside. By using wood as the supporting structure, the occurrence of **thermal bridges**[8] is limited. Thanks to this construction, the ENTIRE shell of the base reaches an U-value of 0.07 W/m².K.

Windows

Where in an average house double glazing is used, passive houses will have triple glazing. Two out of three panes are covered by a heat reflecting material. This material causes the reflected rays of light (now in the form of infrared light, which is heat) to be brought back into the passive house (comparable to the functioning of a greenhouse). The windows also need hermetic seals and specially designed window frames. As an extra insulation measure, the space between the panes is filled with Argon or Krypton. This way, the U-value of the windows is raised to a maximum of 0.8 W/m².K.

Figure 14: A section of the shell of the PEA station

From the inside to the outside, the walls of the station consist of:

- woollen felt (stuck to the next layer by means of velcro) as the finishing layer;
- aluminium foil shield to protect against water vapour (small pore barrier) and thus prevent liquids from the inside penetrating the wood;
- kraft paper (very strong paper made from Abaca (Musa textilis), a type of banana);
- 74 mm thick glued and laminated fir layer (a);
- 400 mm thick low density graphite charged polystyrene layer (principal insulation layer) (b);
- 42 mm thick glued and laminated fir layer (c);
- 3 mm thick resistance layer, which is at the same time a waterproofing layer for the wood, preventing liquids from moving to the inside (d);
- 5 mm thick layer of foam with closed cells (e);
- 1.5 mm thick stainless steel plate (f).

For thermal insulation, a graphite polystyrene layer is used, which considerably increases the insulating value.

Moreover, a useful side effect of this solid permanent building is its resistance against the existing powerful gusts that sweep the polar landscape at a speed of up to 300 km/h.

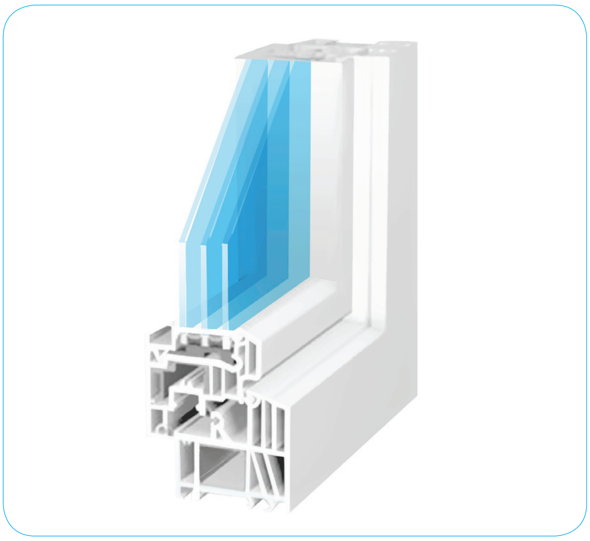


Figure 15: A passive house window with a special frame

The windows in the base do not have triple glazing, but two sets of double glazing, which means they actually have quadruple glazing. Each double glazing contains a thin film that serves as a UV filter and both are separated from each other by a 400 mm wide air-filled cavity. The pane exposed to the outside air is made of armoured glass. The pressure between both double glazing windows can be regulated by means of an air pressure valve.

8 A thermal bridge is a location in an insulated area where cold can penetrate or heat can escape.

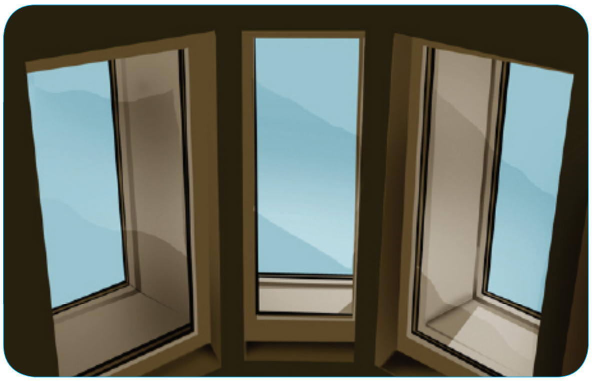


Figure 16: Two double glazing windows, with in between a 400 mm thick cavity, separate the inside from the outside world

AIR TIGHTNESS

Air only needs a few millimetres to squeeze through and cause a cold draught. In order to prevent this from happening, it is important to close off every potential opening or cold bridge. Thermal bridges are mainly located around the window frames and at joints between walls of floors.

Whether in an average house or a passive house, it is always important that the building is airtighted, not only for the purpose of saving energy but also for improving human comfort and preventing mildew. If there were no hermetic layer installed, condensation could occur in the walls and cause damage. It is important to cover the entire surface of the house with an airtight foil along the inside of the insulation layer when trying to build an airtight house. In some cases, an extra airtight layer is placed at the outside of the insulation layer.

Openings can also be prevented by minimising the number of doors and providing them with special hinges and seals.

The station consists of different modules, which fit together like a lock-and-key system. The seams between the wall modules are sealed in such a way that no air can penetrate. Preventive insulating foam is installed between the two wall modules to prevent air leaks at all times. A thin **EPDM layer**[9] in the walls creates an airtight shell around the station as well. The windows are sealed with silicones that are specially chosen for their resistance against ultraviolet radiation, their permanent elasticity and their long life. The few doors that there are - one in the tower, two in the roof, the doors to the garages at the bottom of the tower and an emergency door at the bottom of the station - are sealed with special solid hinges.

In conclusion:

An excellent thermal insulation, a regulated ventilation system with counter-current heat exchangers for recycling heat and an air-tight design were all integrated in the general construction of the station and are techniques commonly used in passive construction. The designers of the station even went a step further to optimise the building, as the U-values were kept much lower and the ventilation system does not only supply heated fresh air but also humidified air. Solar and wind energy are also used in an optimal way. In addition, 75% of the wastewater is recycled. There is one major difference between the station and a passive house, however: in order to prevent overheating, the largest window surface is not placed facing the side of the station that receives the most sun.

All this makes the Princess Elisabeth station a permanent and energy-efficient building and it can even be called a 'zero emission' station. As a result, the Princess Elisabeth station can be regarded as a revolutionary version of the passive house. Without a doubt, the technical innovations can be applied to the house of tomorrow: your house!!

9 EPDM stands for Ethylene Propylene Diene Monomer; the chemical components of which the material is made.

EDUCATIONAL NOTE

1) NOTE FOR THE TEACHER

The Princess Elisabeth Antarctica station is also the first 'zero emission' station. How did it receive this title? We've heard this question frequently and the answers can be found in the dossier 'The technical side of the Princess Elisabeth station'. The station was built on the Utsteinen ridge during the austral summer of 2007-2008. However, the technologies and technical systems will not be installed until the following summer. Nevertheless, it has already been determined how and where these techniques will be applied. Many of these technologies can be linked to activities for young people. Some of these activities can be found in this dossier.

2) OBJECTIVES[10]

Different aspects from the (natural) sciences and technical education are applicable.

Technical education

The students become acquainted with techniques and can describe them. They can illustrate some ways of generating, converting and using energy, as well as environmental effects of recycling, reusing and littering. They can also learn some technical concepts and components of a technical system by creating a simple schedule (list of materials and/or symbols).

Sciences

Through research, the students learn the basic principles of a wind turbine, a solar cell, etc. They are able to relate the experiments or observations made in class to real-life situations. They can also illustrate the interaction between the natural sciences, technological developments and living conditions of human beings with a concrete example. When carrying out the assignments, the students should be prepared to collaborate and follow instructions and rules.

Students can also consult written and electronic sources of information in order to assess and indicate the importance of 'sustainable development'.

They can also describe the interaction between electromagnetic radiation and matter regarding phenomena such as the photoelectric effect and electromagnetic spectra.

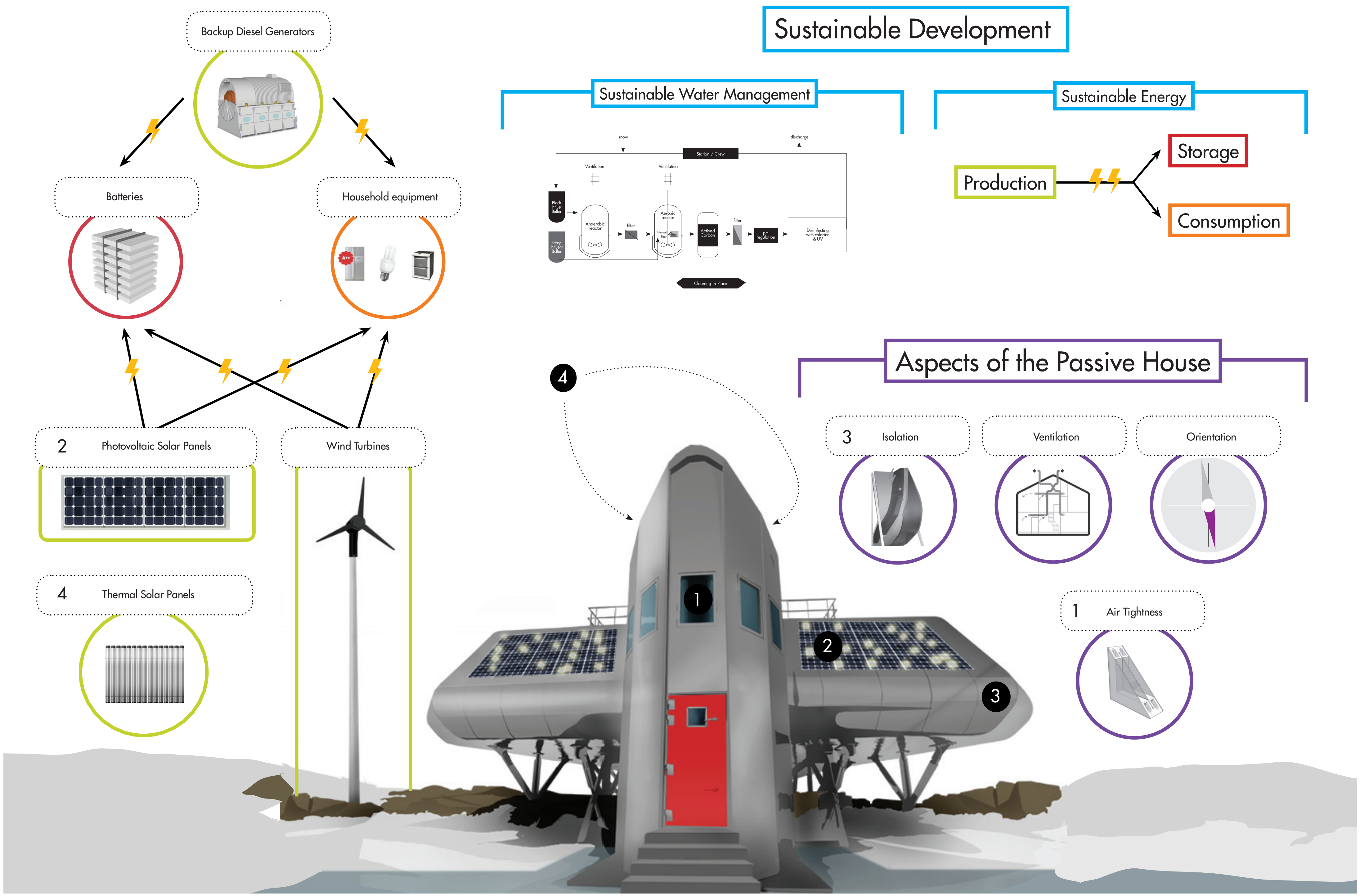
Of course interdisciplinary topics are also dealt with: ICT, learning to learn, environmental education and social skills.

3) SUGGESTED ACTIVITIES
(ALSO SEE THE WORK SHEETS FOR PUPILS)

1) Sustainable development and the passive house

Length: 1 to 2 periods
Target group: High school
Subject: Sciences
Objective: The students can gain some technical notions and indicate components of a technical system by means of a simple schedule.

10 http://www.ond.vlaanderen.be/DVO/secundair/index.htm


Sustainable Development
Sustainable Water Management
snow
discharge
Station / Crew
Ventilation
Ventilation
Black Influent Buffer
Grey Influent Buffer
Anaerobic reactor
Aerobic reactor
filter
Actived Carbon
filter
pH regulation
Desinfecting with chlorine & UV
Cleaning in Place
Sustainable Energy
Production
Storage
Consumption
Backup Diesel Generators
Batteries
Household equipment
2 Photovoltaic Solar Panels
Wind Turbines
4 Thermal Solar Panels
Aspects of the Passive House
3 Isolation
Ventilation
Orientation
1 Air Tightness
1
2
3
4

2) Building your own wind turbine

Length: 1 to 2 periods
Target group: Middle School
Subject: Sciences, technical education
Objective: The students should be capable of relating the experiments or observations made in class to real-life situations. When carrying out the assignments, the students should be prepared to collaborate and follow instructions and rules.

What do you see? Explain.

The LED lamp will turn on. The grooves of the screw are all in a certain direction. The wind pushes the blades and makes them move in a certain direction due to their inclination. This rotates the axis of the engine rotate, which in turn makes the copper wire coil rotate in the engine. This rotation, connected to the electrical wires, causes an electric current to flow through the LED lamp.
SOURCE: L'énergie en pratique, La boîte énergie - WWF

Length: 1 to 2 periods
Target group: High school
Subject: Sciences, technical education
Objective: The students should be capable of relating the experiments or observations made in class to real-life situations. When carrying out the assignments, the students should be prepared to collaborate and follow instructions and rules.

- Energieonderzoek Centrum Nederland/Energy research Centre of the Netherlands (ECN) - http://www.ecn.nl/wind/extra/for-kids/ (NL, EN)
- Vlaams Instituut voor de Zee (VLIZ) - http://www.planeetzee.org/HOMEPAGE/homepage.html (NL) by clicking on "4" and on "Contacteer de Zeeleeuw".
- Re-energy.ca - Renewable Energy Project - http://www.re-energy.ca/t-i_windbuild-1.shtml (EN)

3) Activities linked to solar energy

Length: 1 to 2 periods
Target group: High School
Subject: Sciences, technical education
Objective: The students should be able to relate the experiments or observations made in class to real-life situations. When carrying out the assignments, the students should be prepared to collaborate and follow instructions and rules.

Making your own solar cell

- Sol Ideas Technology Development - http://www.solideas.com/solrcell/bldcell.html (EN, FR, NL, D, E, R, J, CH)

Making your own solar BBQ / oven

- Technopolis - http://www.technopolis.be/content/user/File/Energie%20eerste%20graad%20SO_pdf.pdf (NL)
- Re-energy.ca - Renewable Energy Project - http://www.re-energy.ca/pdf/solaroven.pdf (EN)

SOURCES

WEBSITES

General

- http://www.antarcticstation.org/ (NL, FR, EN) - The press report gives a wealth of information
- http://www.wikipedia.com/
- http://www.duurzame-energie.nl/ (NL) - Everything about renewable energy
- http://domsweb.org/ecolo/index.php (FR) - Survey of alternative energy sources
- http://www.ode.be/ (NL) - Organisation for Renewable Energy
- http://www.eia.doe.gov/kids/index.html (EN) - Facts on energy, games, history, activities for in class, etc
- http://mineco.fgov.be/energy/home_nl.htm (NL, FR, EN, DE) - General trends in energy policy, information on sustainable development but also on the various energy sources and the official petroleum and electricity rates and statistics
- http://www.energiesparen.be/ (NL) - Everything for living in an energy efficient way

Wind energy

- http://www.provenenergy.co.uk/ (EN, FR, DE) - Supplier of the wind turbines
- http://www.planeetzee.org/K3/index.html (NL) - Educational project elaborated by the Flanders Marine Institute (VLIZ)
- http://www.bwea.com/ (EN) - The British Wind Energy Association
- http://www.ewea.org/ (EN) - European Wind Energy Association
- http://www.vwea.be/ (NL) - Vlaamse WindEnergie Associatie
- http://www.gwec.net/ (EN) - The Global Wind Energy Council
- http://www.windpower.org/en/core.htm (Dk, EN) - Danish Wind Industry Association

Solar energy

- http://www.kyocera.eu/ (NL, FR, EN) - Supplier of the photovoltaic solar panels
- http://www.epia.org/(EN) - The European Photovoltaic Industry Association
- http://www.pvresources.com/ (EN, DE, E) - Everything about photovoltaic systems
- http://micro.magnet.fsu.edu/primer/java/solarcell/ (EN) - Animation about the functioning of a solar cell
- http://science.nasa.gov/headlines/y2002/solarcells.htm (EN) - Functioning of a photovoltaic cell

Water purification

- http://www.epas.be/ (NL, EN) - Supplier of the water purification system
- http://www.lenntech.com/ (NL, FR, EN, DE, E, I, PL) - Water and air purification

Passive house

- http://www.lamaisonpassive.be/ (FR)
- http://www.passiefhuisplatform.be/ (NL, FR, EN)
- http://www.passivhaustagung.de/Passive_House_E/passivehouse.html/ (EN, DE)
- http://passivhaus-vauban.de/passivhaus.en.html (EN, FR, D en TR)