EXPERIMENT MANUAL

Green Engineering

Clean Energy & Sustainable Living

THAMES & KOSMOS

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KIT CONTENTS

What's inside your experiment kit:

Good to know!
If you are missing any parts, please contact Thames & Kosmos customer service.

Checklist:

✓	No.	Description	Quantity	Item No.
	1	Model house punch boards 1, 2, and 3	1	728012
	2	Sticker sheet	1	729833
	3	Ryegrass seed packet	1	729639
	4	Cotton pad	1	728011
	5	Robotic mower with charging cable	1	728547
	6	Water pump	1	728543
	7	LED set with phototransistor and cable	1	728546

✓	No.	Description	Quantity	Item No.
	8	Battery station with ports	1	728548
	9	Solar cell with cable and adhesive, spare included	1	728542
	10	Transparent measuring cup	1	061150
	11	Silicone hose (90 cm)	1	728544
	12	Transparent window film	1	728016
	13	Printed screen film	1	729638
	14	Green roof plastic tray	1	728541
	15	Wall-mounted hose holder	1	728545
	16	Thermometer strip	1	728873
	17	Nano-adhesive pad	1	726527

Parts not included in the box are listed under "You will need" in italics.

YOU WILL ALSO NEED: *3 AA rechargeable batteries (1.2-volt, type HR6, NiMH), pen or pencil, scissors, water, ice cubes, tape, glue stick or craft glue, ruler, small cup or bowl, aluminum foil, fabric scraps or Styrofoam, needle or sim card pin*

TABLE OF CONTENTS

TIP

ADDITIONAL INFORMATION CAN BE FOUND IN THE CHECK IT OUT SECTIONS ON PAGES 11, 16, 17, 23, 24, 28, AND 32

Ready? —let's go!

Warning!

Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled. Strangulation hazard - long tubes and cables may become wrapped around the neck.

WARNING: This toy is only intended for use by children over the age of 8 years due to accessible electrical components.

Instructions for parents or caregivers are included and shall be followed.

Keep packaging and instructions as they contain important information.

Safety for Experiments with Batteries:

- To operate this kit, you need three 1.2-volt rechargeable AA batteries of type HR6, NiMH. Due to the limited lifespan of batteries, these are not included in the set.
- The batteries are not to be short circuited. A short circuit can cause the wires to overheat and the battery to explode.
- Different battery types (e.g. rechargeable battery and non-rechargeable battery) or new and used batteries must not be mixed.
- Do not mix old and new batteries.
- Do not mix alkaline, standard (carbon-zinc), or rechargeable (nickel-cadmium) batteries.
- The batteries are to be inserted with the correct polarity (+ and -). Press them gently into the battery compartment (see page 4). The battery must be inserted by an adult.
- Non-rechargeable batteries are not to be recharged. They could explode!
- Batteries are only to be charged by persons at least 8 years old.
- Exhausted batteries are to be removed from the toy (if no experiments are to be carried out with them for a prolonged period of time).
- The supply terminals are not to be short-circuited.
- Dispose of used batteries in accordance with environmental provisions, not in the household trash.
- Avoid deforming the batteries.
- The wires must not be inserted into a socket.
- Warning! The protective device in the battery compartment (PTC) must not be tampered with. This could lead to overheating of cables, battery failure, and excessive heating.
- The toy must not be connected to more than the recommended number of energy sources, i.e. only use the included battery compartment.
- Do not use any energy source other than than the battery compartment with the batteries inside, which should only be charged either via the connected solar cell or via the USB-C port.
- This toy may only be connected to devices of protective class II or devices of protective class III that bear one of the following symbols:

The Green Engineering pump may only be operated in water if it has been fully assembled according to the instructions.

Notes on Disposal of Electrical and Electronic Components

The electronic components of this product are recyclable. For the sake of the environment, do not throw them into the household trash at the end of their lifespan. They must be delivered to a collection location for electronic waste, as indicated by the following symbol:

Please contact your local authorities for the appropriate disposal location.

IMPORTANT INFORMATION

Dear Parents, Teachers, and Supervising Adults

**Children want to explore, understand, and create new things.
They want to try things and do it by themselves. They want to gain knowledge!
They can do all of this with Thames & Kosmos experiment kits.
With every single experiment, they grow smarter and more knowledgeable.**

This experiment kit provides your child with a customizable and functional model house for experimenting, researching, and observing. The complex topic of **sustainable living** is made tangible in a playful way for young researchers through the use of realistic miniature devices.

Before experimenting, read the instructions together with your child, discuss the safety instructions together, and keep them ready for reference. Check that the electronic components of the Green Engineering kit have been assembled correctly and accompany your child during the experiments.

The batteries (3x rechargeable AA 1.2-volt, type HR6, NiMH) must always be inserted into the battery compartment by an adult due to the risk of confusion with non-rechargeable batteries. To do this, open the battery compartment with a needle or a paper clip, as described on page 4. Please keep the needle/paper clip separate from the box and out of the reach of children. Make sure that your child connects the parts (the robotic lawnmower, the pump, and the LED set) correctly to the appropriate connection on the battery compartment and only uses the pump in water — other liquids are not permitted. Make sure that your child does not scald themselves when handling the warm water and the pump. When not in use, allow the parts that come into contact with water to dry thoroughly.

A solid table with a durable surface is suitable as an experimentation area (cover the table if necessary). When handling water, care should be taken not to wet the model house. Check the cotton pad and the grass growing on it regularly for mold and remove any moldy materials immediately.

To charge the batteries via the solar cell, the sun must shine on it directly or through a clean pane of glass, ideally at midday. When you place the model house outside, make sure it is in a visible place, and the weather is dry and windless. The charging function via the solar cell can also be implemented using a halogen lamp. The batteries can also be charged via the USB-C port with a USB-C cable (not included) connected to a power source.

This experiment kit is not suitable for children under 8 years of age and should therefore be kept out of their reach.

We hope you and your child have lots of fun with Green Engineering!

Have fun!

Open the battery compartment and insert the batteries

Please have an adult perform this task!

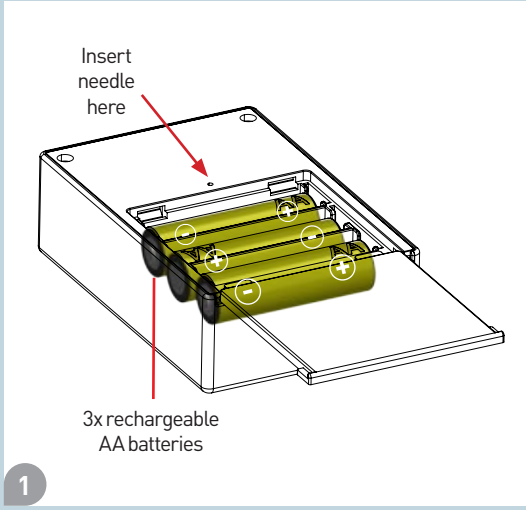
To open the battery compartment, you need a pointed, very thin object, such as a sewing needle or pin or a straightened paper clip, which should be kept separate from the experiment box and out of reach of children.

Carefully push the needle into the small hole on the underside of the battery compartment (see arrow in figure 1). At the same time, slide the battery compartment cover off.

Please note! Only rechargeable 1.2-volt AA batteries of type HR6 (NiMH) may be inserted into the battery compartment. Non-rechargeable batteries must not be inserted.

Insert the Batteries:

To operate the model house, three rechargeable AA batteries (1.2-volt, type HR6, NiMH) are required. **These should not be charged at the time of insertion in order to use the full functionality of the model house.** After removing the battery compartment cover, insert the three batteries into the compartment as shown above. Please ensure that the polarity is correct (figure 1)! Push the cover back onto the compartment until it clicks into place.



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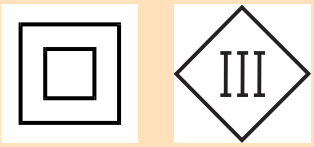
PROTECTIVE CLASSES

The two symbols mean that you may only connect the house's battery station via the USB cable to devices that also have these symbol. Devices with these symbols have special protections against excess voltage and short circuits built in.



YOUR Model house...

... can be quickly assembled, and then all you need to do is equip it with technology and decorations. Attach the solar cell that will later supply your house with electricity, install the lighting and the heating and cooling devices, then decorate the house with stickers. Once you've done all that, you can start experimenting with your own model house: How does sustainable living work?

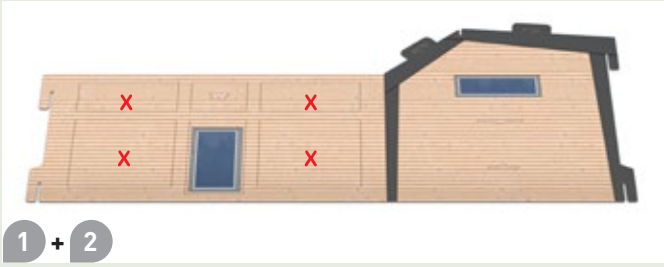
Assembling the model house

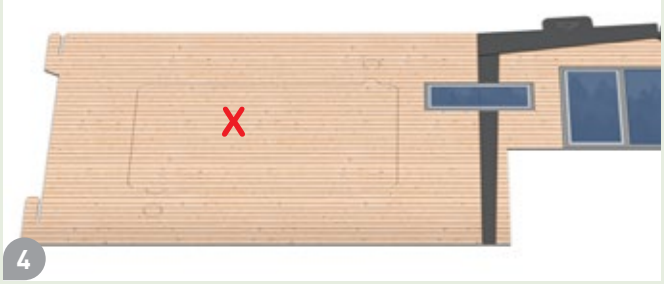
You will need

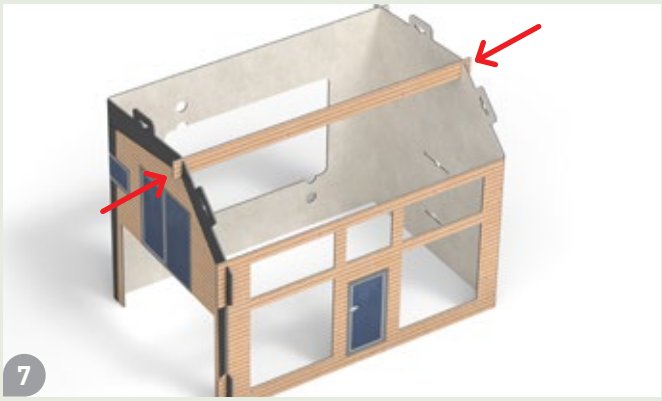
- **Model house punch boards 1 and 2**

Here's how

1. Press the house front and right side out of punch board 1.
2. Press the windows and small cutouts out of the house front. Optional: you can use the parts marked with red Xs to make furniture for your house.
3. The part marked in red in figure 3 will become the door handle for the door below. Insert the shorter side into the slot in the door.
4. Now press the back of the house out of punch board 2. Remove the large part marked with a red X in figure 4 and keep it. You will need it later!
5. Fold the front of the house away from the right side, and form a right angle. Repeat with the back of the house and the left side.
6. Put the house together at the two open edges using the tabs provided, as shown in figure 6.
7. Insert part B from punch board 1 into the slots in the left and right walls to create a roof beam.







Assemble the interior of the model house

You will need

- **Model house punch boards 1, 2, and 3**
- **Printed screen film**
- **Silicone hose**
- **Wall-mounted hose holder**
- **Thermometer strip**
- **Water pump with cable**
- **LED set**
- *Glue stick or craft glue*
- *Tape*
- *Ruler and scissors*

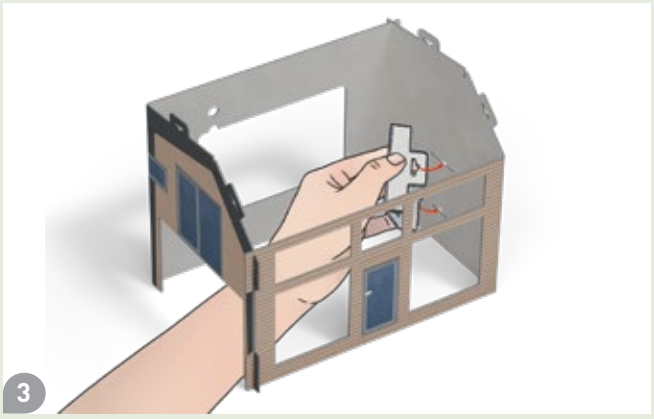
Here's how

1. If your house looks like the model in figure 1, it is now time to assemble the parts inside. Separate the screen frame part (figure 1b) from punch board 3 and remove the interior.
2. Fold the screen frame at the pre-scored edges. Add glue around the inside of the screen frame, as shown in figure 2. Then place the printed screen film on top of the glue and press down around the edges.
3. Insert the screen with the tabs at the top and bottom through the slots on the inside of the right side of the house (figure 3). Attach the upper tab to the outside of the house using tab A from punch board 2.


1


1b


2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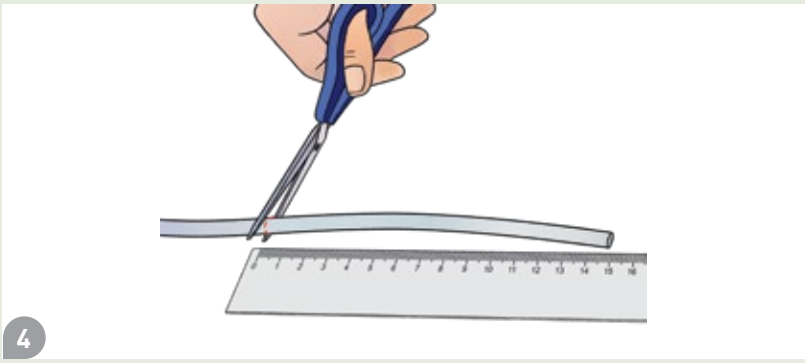
4. Take the silicone hose and measure a piece that is 15 cm long. Cut this piece off and put it in the green roof plastic tray. You will need it there later.

5. To assemble the climate control module, remove the top cover from the wall-mounted hose holder. Now press the remaining silicone hose into the curved recesses. There should be about 15 cm of hose sticking out on each side. Replace the top cover.

6. Place the climate control module into the back wall of the house from the outside. The top cover should be facing the inside of the house. Before pushing the module all the way in, thread the two ends of the hose through the two holes in the back wall from the inside to the outside. Attach the water pump to the end of the hose that is near the bottom left corner of the house.

7. Stick the thermometer sticker inside the house on the top cover of the climate control module. Make sure it isn't upside down!

8. Use tape to attach the LED set as follows: Attach the circuit board with the light sensor to the left inner wall a little below the top edge. Don't stick it too close to the top edge of the wall! Place the black power cable in the notch in the top edge of the left wall, so it can reach the battery station. Line up the two cables of the LEDs along the roof beam. The LED with the shorter cable will dangle and become the lamp. Put the LED on the longer cable through the hole in the top of the screen frame. Then secure the cables to the roof beam with adhesive tape.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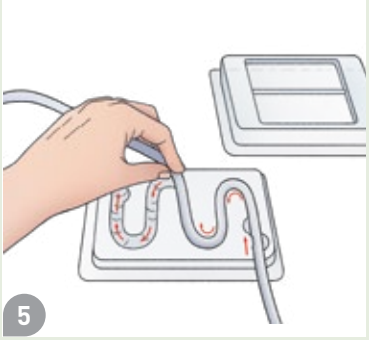
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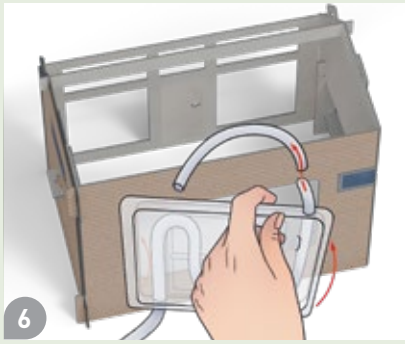
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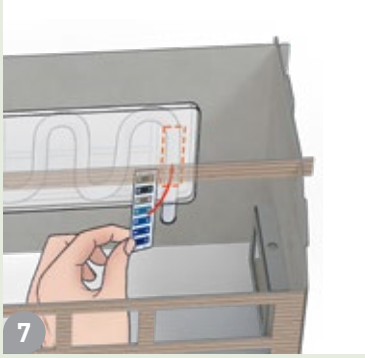
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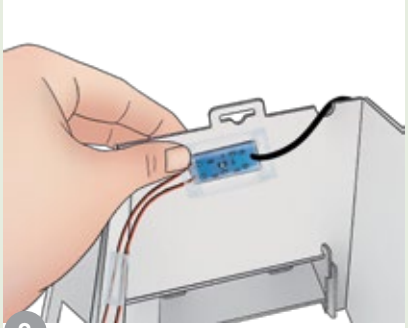
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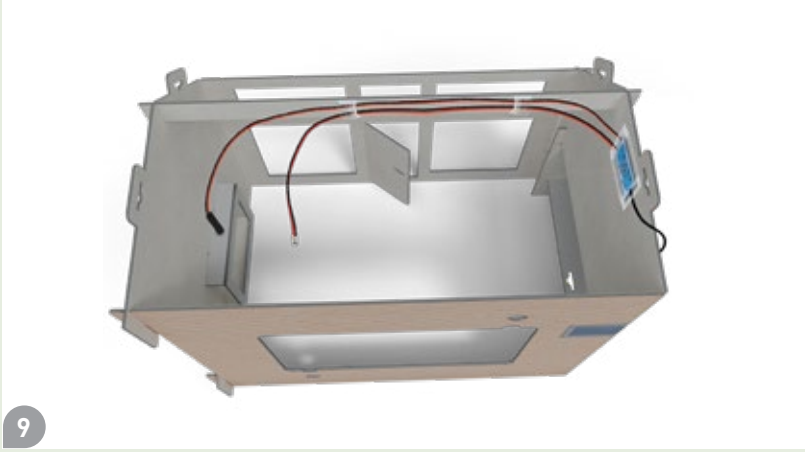
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ASSEMBLY

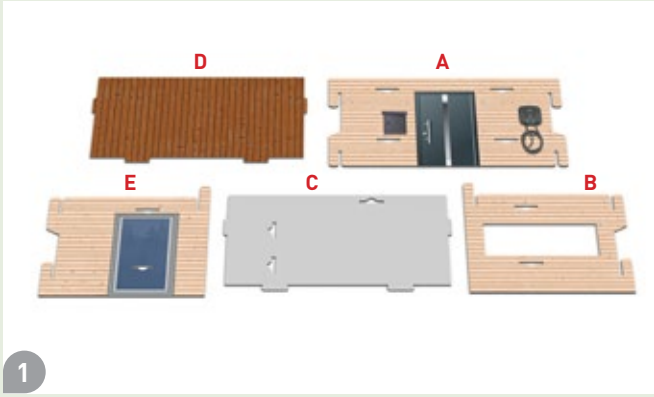
Assembling the extension

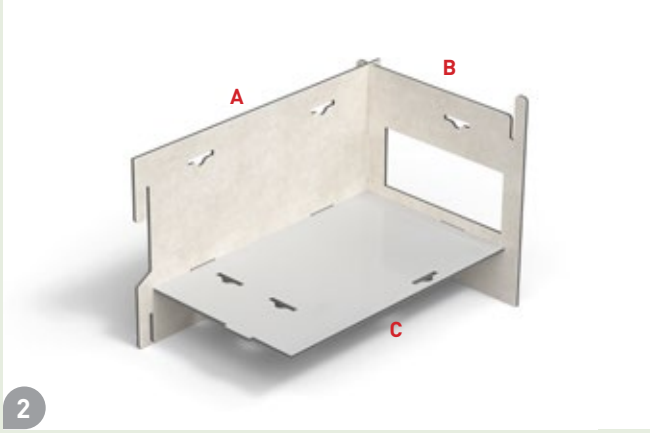
You will need

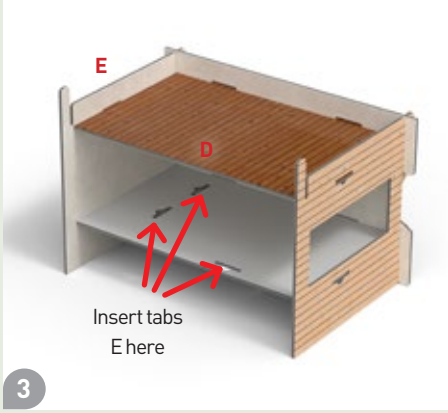
- **Model house punch boards 1, 2, and 3**
- **Battery station**
- **Solar cell with cable and adhesive**
- **Green roof plastic tray**
- **15 cm silicone hose**
- **Cotton pad**
- **Transparent window film**
- **Measuring cup**
- **Sticker sheet**
- *Tape*

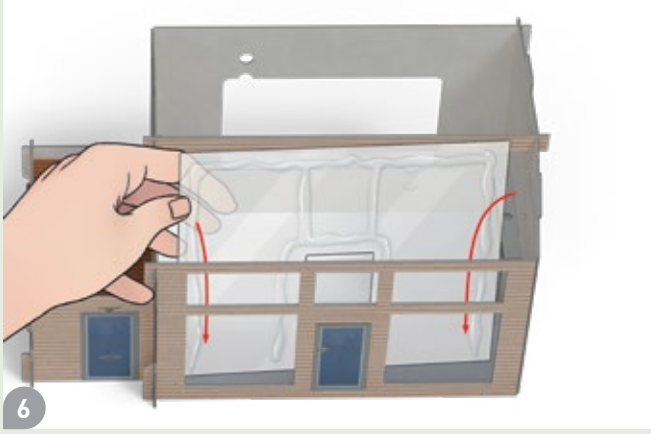
Here's how

1. Press the parts for the extension out of the punch boards. Slot panels A and B into each other at the corners. Make sure that the printed sides face outwards.
2. Then insert the floor for the battery station (C), with the gray side face up.
3. Then place the balcony floor (D) with the side face up. Slot panel E into panel A at the corners, and make sure the tabs for both horizontal panels are in the slots. Insert tabs E securely into the slots on the floor.
4. Slide the extension into the opening in the left side of the main house so that it sits securely.
5. Insert the battery station from inside the house with the ports facing the opening in the rear wall of the extension and slide it so that it sits securely between the tabs in the floor.
6. Glue the transparent window film to the inside of the front of the house so that all windows are covered with the film.









Finishing your house

Here's how

1. Take the yellow lampshade from the sticker sheet and carefully cut it along the dotted lines. Ask an adult for help if you need help! Then wrap the lampshade around the hanging LED so that the sticker parts overlap.

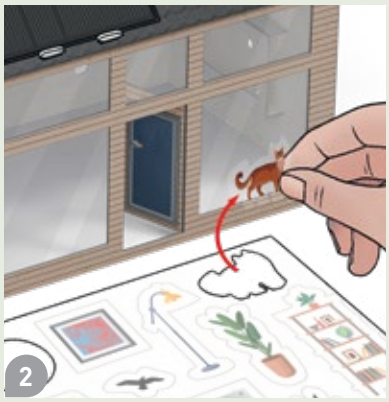
2. Now you can decorate your house with the stickers!

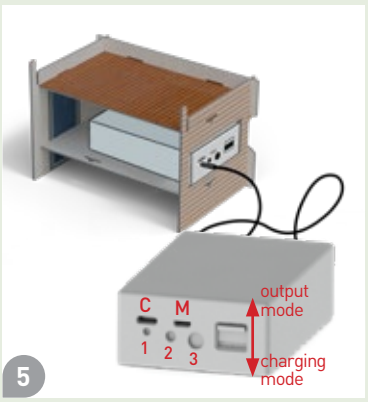
3. Install the roof on the house by placing it with the slots over the tabs. Fasten it with the four D tabs.

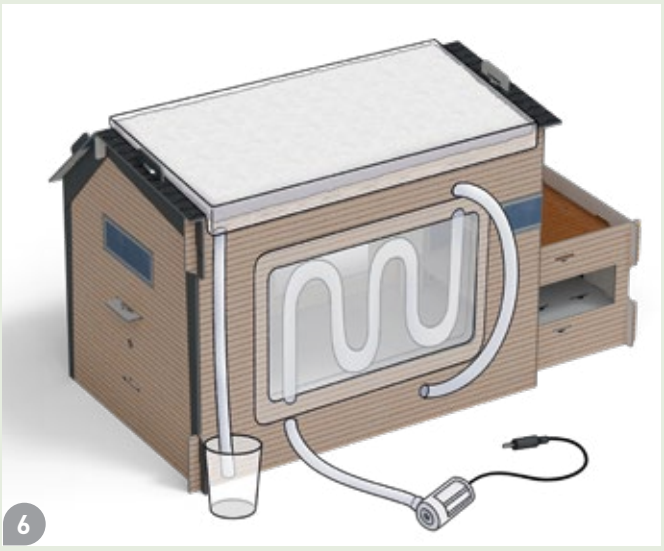
4. Next, attach the two C tabs from punch board 1 to the front of the roof. Press them in firmly to secure them. Peel the film off one side of the double-sided foam adhesive pad and stick it to the middle of the solar cell. Then peel the backing from the other side of the adhesive pad and stick the solar cell to the roof so that it rests on tabs C and the cable is at the top. Remove the protective film from the solar cell.

5. All cables (the solar cell, the LED set, and the water pump) should now be able to be easily plugged into the ports on the battery station via the opening in the house extension. The switch on the right allows you to switch between charging mode (when the switch is at the bottom) and power output mode (when the switch is at the top). In charging mode, plug the solar cell into the micro USB port (M). The batteries can also be charged without sunlight via the USB-C port (C).

6. Peel the nano-adhesive pad away from its backing, and stick it to the center of the larger roof panel. Next, peel the translucent film off of the nano-adhesive pad. Place the green roof plastic tray on the roof so that the gutter protrudes from the back wall. Attach the 15 cm piece of silicone hose to the outlet in the left corner of the gutter. Place the cotton pad in the plastic tray and place the measuring cup at the bottom of the hose as a rain barrel.







CHECK IT OUT

Energy for Living

Houses consume energy, but how much energy and where that energy comes from varies widely from house to house. As you will discover later through your own experiments, houses with poor insulation need a lot of energy to keep warm in cold weather and cool in hot weather. Drafty windows and doors, large open spaces with high ceilings, and outdated and inefficient appliances can also all lead to more energy usage.

These days, most new buildings have to comply to energy standards set by national and local governments. In the US, there are many different types of assessments that a house can undergo to determine its energy efficiency. Some other countries have national standard tests, similar to building code inspections.

The most energy efficient houses are known as passive houses and zero-energy houses. In a passive house, no heating energy is required at all, because the heat required is generated by sunlight, good insulation of the walls and windows, the body heat of the residents, and by recovering the waste heat from appliances (washing machine, refrigerator, etc.).

A zero-energy house, on the other hand, has its own active energy generators, such as solar panels. It therefore does not require any other energy supply, like oil, gas, or electricity from outside sources, but is also significantly more expensive to build and maintain than a passive house. However, it usually "earns back" these additional costs over the course of a few years through savings on electricity and heating materials. Sometimes, electric companies will even pay for excess generated electricity to be fed into the local grid.

Energy for your house

Next, you will supply your house with something without which our modern lives would not be recognizable: electricity. In a house or apartment, there are countless devices that require electricity. Think, for example, of the lights in the rooms you live in. An internet network, the refrigerator, the kettle, and even the doorbell also require electricity. Your model house gets its electricity from a small solar cell on the roof. In this section, you will learn what electrical loads are, how renewable electricity is produced, and how a house can save electricity.

EXPERIMENT 1: SOLAR CELL AND BATTERY STATION

Store energy from the sun

Learn how to green your roof on page 26!

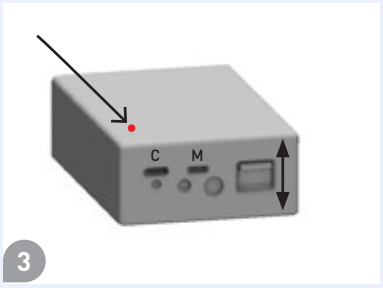
You will need

- **Assembled model house**
- *Direct sunlight*
- *3x empty rechargeable 1.2-volt AA batteries (HR6, NiMH)*

2

Here's how

1. Before you can charge the batteries with sunlight, three empty 1.2-volt AA batteries must be inserted into the battery station.
   Ask an adult to do this for you (see page 4).
2. Find a safe place for the model house where the solar cell is directly exposed to the sun, preferably facing south. This could be a windowsill or a balcony table, for example. Important: Only place the house outside in dry, windless weather!
3. Plug the solar cell cable into the M port on the battery station. The red LED light on the battery station indicates that it is successfully charging. If this is not the case, the sunlight is not strong enough. Midday sun is best.
4. If you cannot expose the solar cell to direct sunlight (because it is cloudy, for example), you can find alternatives in the tip box below. You can also charge the batteries via the USB-C port on the battery station (C). To do this, insert a USB-C cable (not included) into port C and connect it to a power source. (Pay attention to the protective classes on page 2).



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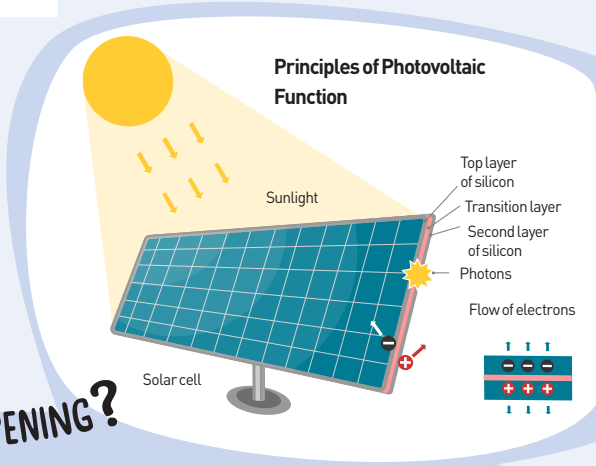


TIP

YOU WANT TO CHARGE THE BATTERIES, BUT THE SUN ISN'T SHINING? SHINE A STRONG HALOGEN LAMP ON THE SOLAR CELL! THE LAMP MUST SHINE DIRECTLY ON THE SOLAR CELL FROM A VERY CLOSE DISTANCE.

WHAT'S HAPPENING?

The solar cell supplies the batteries with renewable energy. The cell is made up of several different layers. The top layer is made silicon, which captures light well. The captured light contains small particles that carry energy, called **photons.** These photons move through the solar cell and hit another layer that contains **electrons —** tiny particles in the solar cell that can carry electricity. When the photons hit the electrons, the electrons break away from their original position. The movement of the electrons creates a flow of **current.** The more sunlight that hits the solar cell, the more electricity is generated — that's why you should face your solar panel toward the south! This technology is called **photovoltaics**. In real houses, the electricity generated by a photovoltaic system can also be stored in batteries, just like in your model house.

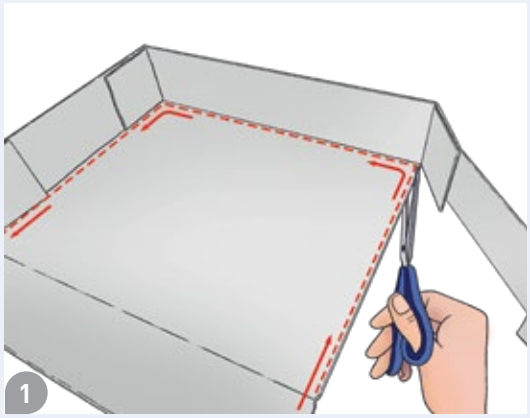
Operating the robotic mower with solar energy

You will need

- **Assembled model house**
- **Charged batteries in battery station**
- **Robotic mower with charging cable**
- **Green Engineering box**
- *Scissors*

Here's how

1. Open the Green Engineering box. On the sides of the lower half you will see a hedge printed. Cut this off the box in one piece using a good pair of scissors.
   Ask an adult for help.
2. Place the hedge as a garden wall in front of your model house. If you like, you can attach it to the ground with tape or even with clay.
3. Push the switch on the battery station upwards to put it in output mode. Plug the charging cable into port 1 on the battery station.
4. Plug the other end of the cable into the robotic mower. Let the robotic mower charge for at least 30 seconds, preferably longer.
5. Hold the mower in one hand and unplug cable from the robot with the other hand.
6. Place the robot inside the garden fence and watch it go!



WHAT'S HAPPENING?

When connected to the battery station, a **capacitor** is charged inside the robotic lawnmower. The capacitor stores small amounts of electrical energy that drives a vibration motor, which in turn moves the robot. When the energy is used up, the motor stops. Real robotic lawnmowers have a battery inside that needs to be recharged after a while. The robotic lawnmower is an **electrical load** in your model house. This refers to devices that require electrical power to function and cannot generate this energy themselves.

EXPERIMENT 3: LIGHTS ON A SENSOR

Operating the LEDs with light sensor

You will need

- **Assembled model house**
- **Charged batteries in battery station**
- **LED set with light sensor**

Here's how

1. Plug the cable running out of the house into port 2 on the battery station. The switch on the battery station must be in the top position.
2. Completely darken the room where the house is located. Casting a shadow on the house is not enough.
3. Observe the two LED lights in the lamp and behind the screen.

1


2

TIP

YOU CAN PLUG ALL ELECTRICAL LOADS (THE ROBOTIC MOWER, THE PUMP, AND THE LED LIGHTS) SIMULTANEOUSLY INTO THE BATTERY STATION.

WHAT'S HAPPENING?

When it gets dark around the house, the LEDs light up. For this to happen, the **light sensor** on the inside wall of the house must be able to detect darkness. This light sensor is a **photodiode,** which changes its electrical conductivity depending on light. When light hits it, it blocks the flow of electricity and the lights stay off.
Similar but more complex technologies are used in houses and apartments so that, for example, lighting is switched on only when it is needed. This saves energy, because like your LED lighting, lamps and lighting require electricity.

Renewable Energies

Humanity is increasingly switching its energy supply to **renewable energy sources** that will not eventually be used up, like coal and oil, and do not produce the greenhouse gas carbon dioxide, which heats up the planet. Renewable energies include the direct use of solar heat in **solar collectors,** the conversion of sunlight into electricity using **photovoltaics,** and the use of **wind energy.** Other renewable energy sources include **hydroelectric power plants,** which generate electricity from the energy of falling or flowing water, and **geothermal power plants,** which tap into the enormous heat reserves within the earth. There are also energy sources that don't rely on fossil fuels, like **biomass power plants,** which burn plants or ferment them to produce biogas, which in turn produces heat and electricity. Then there are **nuclear power plants** that use energy-rich elements such as uranium or thorium.

Renewable energies also have limitations: wind turbines and solar panels, for example, do not generate electricity when there is no wind or sunlight. To fill the gaps, reserve power plants must be kept on hand or electricity must be imported from abroad. Wind turbines can also pose a fatal threat to birds and bats, nuclear waste is difficult to store, and areas used for biomass production are unavailable for growing food.

Storing solar energy?

The generation of electricity from sunlight suffers from the fact that clouds and winter days with little sun can significantly reduce the performance of solar cells. They also do not produce any electricity at night. On sunny days, however, solar systems may produce more electricity than is needed in the house that day. There are several technical ways to deal with this problem: you can feed excess electricity into the public power grid, and even get paid for it. Or you can store it in large battery systems to use when there is no sun. You can also automatically switch on larger electrical devices in the house only during times when there is a surplus of electricity. An electronic control system then distributes the electricity only to where it is needed. For example, to the washing machine, to the heating in winter, to the air conditioning on hot summer days, or to a charging electric vehicle.

KEYWORD

Smart Home

In many houses and apartments, electrical energy is wasted, usually through carelessness or convenience. Electronic controls, often connected to the internet and controllable via apps, can reduce this unnecessary electricity consumption. For example, they only switch on lights when someone is moving in the room and it is dark. They control the heating and turn it down when the sun is warming through the window. They open and close shutters to achieve optimal insulation at night, even when no one is in the house. A house equipped in this way is called a **smart home**. Whether such technology is installed in a house must be carefully considered: scrapping functional devices and technology to replace them with "smart" technology may be a waste of resources.

HEATING AND cooling

It's not just electrical devices such as household appliances or computers that need energy to function: energy is also used to create a comfortable living temperature. If you live somewhere on Earth where there are seasons with cooler temperatures, your living space will need to be heated using energy. In other regions of the world, however, houses may need to be cooled. A lot of places need both. Your house has a simplified system that you can use to research heating and cooling in a model. You'll explore how a house can be heated or cooled in the most energy-efficient way possible.

EXPERIMENT 4: HEATING THE HOUSE

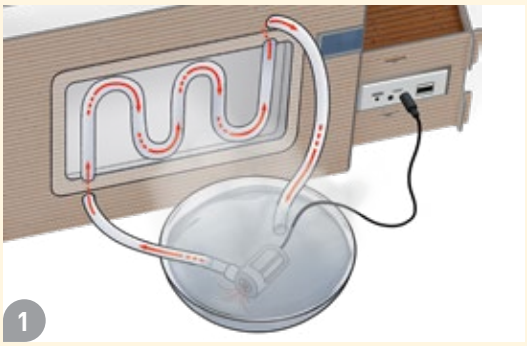
Heating the house

You will need

- **Assembled model house**
- **Charged batteries in battery station**
- **Water pump and climate control module**
- *Shallow bowl or dish*
- *Warm water*

Here's how

1. To operate the water pump, it must be completely submerged in water.
   Important: Test the pump without putting the hose in the water by plugging it into port 3 on the battery station.
2. For this experiment, you need a temperature difference between the water and the ambient air. Therefore, fill the bowl with very warm tap water.
   Important: Have an adult help you, and be careful not to scald yourself. Make sure that the other electronic parts and the cardboard parts of the house do not come into contact with the water.
3. Put the water pump into the bowl of warm water. Put the open end of the hose in the water or fix the hose to the bowl so that the water runs into the bowl.
4. Plug the water pump cable into port 3 on the battery station. If the pump is unable to pump the water through the entire hose, recharge the batteries in the battery station.
5. Observe the thermometer strip.



WHAT'S HAPPENING?

You can see a rise in temperature on the thermometer strip. The warm water that is pumped through the hose heats the climate control module and the surrounding air. In very simplified terms, a classic heating system also works according to this principle: water is heated and pumped in a circuit through pipes, which then heat the living spaces. These pipes run in radiators or, in the case of underfloor heating, in the floor.
In your experiment, the water was already warm. In real heating systems, the water in the heating circuit has to be heated: this can be done, for example, by burning heating oil, gas, or wood pellets. However, fossil fuels such as gas or oil are not renewable, and they also release greenhouse gases. This drives climate change. Therefore, renewable energy sources such as biogas or wood pellets — or even completely different heating technologies such as heat pumps or geothermal heat — are sometimes used today.

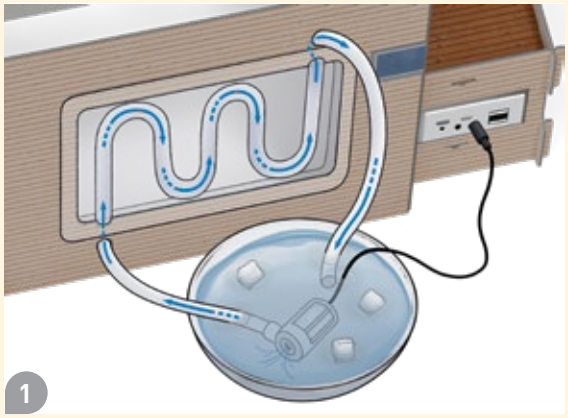
TIP

THE THERMOMETER STRIP SHOWS THE TEMPERATURE BY COLORING THE BLOCKS IN 5°C INCREMENTS. IF TWO BLOCKS ARE COLORED, THE TEMPERATURE IS IN BETWEEN. IF THREE BLOCKS ARE COLORED, THE MIDDLE BLOCK IS THE ACTUAL TEMPERATURE.

Cooling the house

You will need

- **Assembled model house**
- **Charged batteries in battery station**
- **Water pump and climate control module**
- *Shallow bowl or dish*
- *Cold water*
- *Ice cubes*



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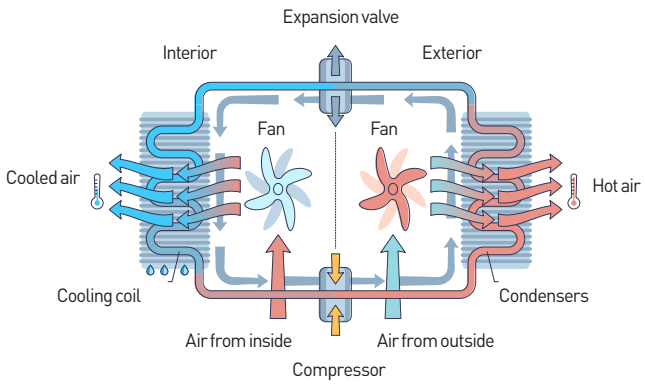
Here's how

1. Pour ice-cold water into the bowl, but do not fill it completely. Add a few ice cubes to the water in the bowl.
2. Put the water pump in the cold water and make sure that the open end of the hose is also in the water. Attach it to the bowl it if it does not stay in the water on its own.
3. Then plug the pump cable into port 3 on the battery station. You can hear the pump start operating underwater. Make sure that the other electronic parts and the cardboard parts of the house do not come into contact with the water.
4. Observe the thermometer strip.
5. Additionally, you can also place a bowl of ice cubes inside the house.

WHAT'S HAPPENING?

Similarly to the previous experiment, the cold water cools the climate control module and the surrounding air. You can see the temperature drop on the thermometer strip. However, real air conditioners do not use water — they use the ambient air and a coolant.
An air conditioner needs electricity to operate the cooling circuit explained in this graphic.

How an air conditioning system works



EXPERIMENT 6: SOLAR HEAT

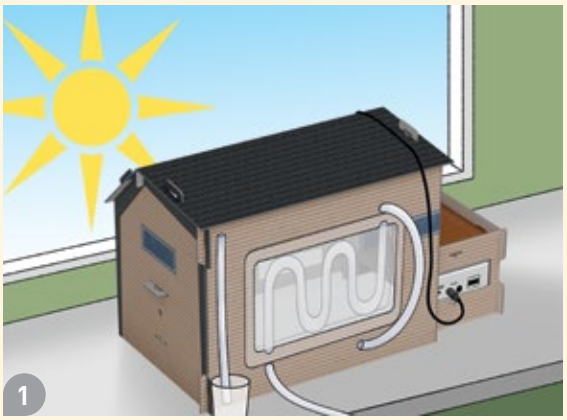
Heating with sunlight

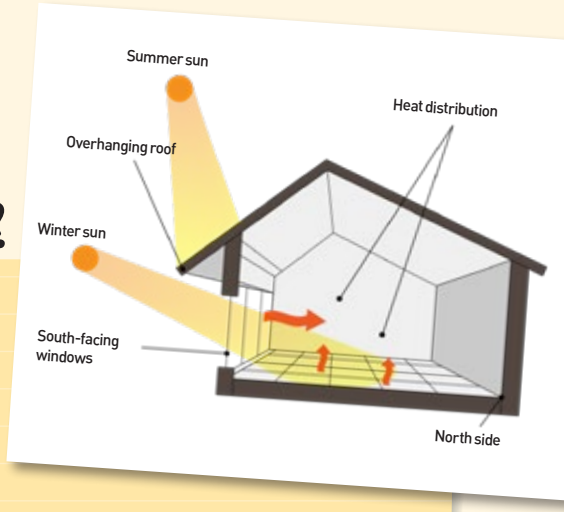
You will need

- **Assembled model house**
- *Sunlight*

Here's how

1. Carefully place the house in direct sunlight This could be a windowsill or a balcony table, for example.
2. Turn the model house so that the sun shines on the windows at the front. Note the temperature shown by the thermometer strip.
3. Leave the house in the sun for at least 30 minutes or longer.
4. Then, observe the thermometer strip inside.





TIP

THIS EXPERIMENT WORKS BEST, WHEN THE SUN IS SHINING BRIGHTLY, AND IS HIGH IN THE SKY. THE SETTING SUN IN THE EVENING DOESN'T HAVE ENOUGH ENERGY TO WARM YOUR HOUSE.

WHAT'S HAPPENING?

You can see a rise in temperature on the thermometer strip. **The sun radiates solar energy,** which heats the interior of your house through the window film. This allows you to save electricity, as you don't need to heat it much or at all. Depending on the position of the sun, you can shift and rotate your model house so that it receives the maximum amount of sunlight.

Of course, this isn't possible with a real house: Therefore, a house that wants to gain heat from the sun must be built in such a way that it always receives the maximum amount of sunlight for its location. For example, in temperate climates, the living and recreation rooms and their windows might be oriented to the south, where they still receive sufficient sunlight even in winter. Stairs, storage rooms and the entrance area can be on the north side, as people don't spend as much time in those areas and need less heat and light there.

Insulate your house

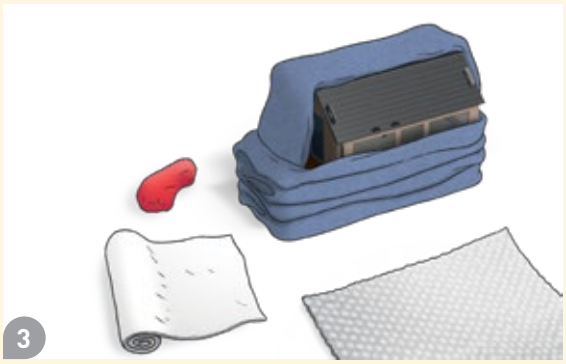
You will need

- **Assembled model house**
- **Charged batteries in battery station**
- **Water pump and climate control module**
- **Cardboard piece A from the back of the house**
- *Insulation materials: Blankets, scarves, cardboard, modeling clay, Styrofoam, etc.*
- *Cell phone or stopwatch*

Here's how

1. Do the heating experiment on page 19 and heat your house with warm water.
2. After about three minutes, check the temperature reached and write it down.
3. Now insulate your house: Place cardboard part A in front of the transition to the extension with the battery compartment. If you like, seal all open cracks on the house with clay. Then cover the house by, for example, building a layer of Styrofoam around it or wrapping it in a thick blanket. The materials should fit as tightly as possible to the house.
4. Set a timer for 3 minutes, then run the heating experiment on page 19 again. After the 3 minutes have passed, remove the insulation from the house and quickly read the temperature shown on the thermal strip. Compare it with the temperature previously measured in the uninsulated house.


1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TIP

YOU NEED A SIGNIFICANT TEMPERATURE DIFFERENCE BETWEEN THE HOUSE INTERIOR AFTER HEATING AND THE SURROUNDING TEMPERATURE, IN ORDER FOR THE EXPERIMENT TO WORK! THE TEMPERATURE DIFFERENCE SHOULD BE MORE THAN 3 -5°.

WHAT'S HAPPENING?

In the first part of the experiment, you should measure a lower temperature than in the second part, once the house has been insulated. This is because heat transfer takes place between bodies with a higher temperature and those with a lower temperature. Your model house has thin walls made of cardboard and paper and the windows are made of plastic film and are not sealed. The house therefore quickly releases its heat into the surrounding air. Sealing and wrapping your house reduces heat transfer to the air. Measures that prevent heat transfer are called thermal insulation. Insulation can be used to save energy. A lack of insulation, as modeled in part 1 of the experiment, means that heat is lost and much more heating is required. You can read more about insulation on page 24!

CHECK IT OUT

Heating sustainably

Natural hot springs in Iceland

Geothermal energy is the use of Earth's heat. Simple home systems use heat pumps to extract heat energy from groundwater. Larger systems tap into the heat of deep rocks. This works particularly well in volcanically active areas, such as Iceland or New Zealand.

With **solar thermal energy,** solar heat is captured using large, dark solar collectors that contain liquid-filled pipe coils. They conduct the heat into the house, where it is used for heating or hot water.

Solar collectors above a photovoltaic system with solar cells

What actually is a heat pump?

If you put a gas under pressure (compress it), it liquefies and heats up. If you remove the pressure, it evaporates again and extracts heat energy from its surroundings. This principle is used by a heat pump. A type of coolant circulates in it that is alternately compressed and expanded. In outdoor pipe coils, it absorbs heat, for example from the air or groundwater. It then releases the heat again through radiators inside the house, at a slightly higher temperature. Although a heat pump uses some electricity for compression, overall it generates more heat than, for example, an electric heater with the same power consumption. In order for it to work well, the house should be well-insulated.

AIR CONDITIONERS – DO THEY MAKE SENSE?

Temperatures that are too high in summer are exhausting: they disrupt sleep and make people tired and unable to concentrate. Not to mention that extreme heat can be dangerous, especially for older people. An air conditioning system can help there. It cools and dehumidifies the air and thus improves the indoor climate. However, air conditioning systems use a lot of electricity. It's therefore best to combine them with photovoltaics — which provide a lot of energy, especially on hot days. Incidentally, there are types of heat pumps that can also cool — instead of transporting heat from the outside to the inside, they work the other way around.

Insulation

Insulating a building prevents heat loss through the facade to the outside, especially in regions where it gets cold in winter. In addition, insulation prevents interior rooms from heating up as much on sunny summer days. Unfortunately, many insulation materials used are porous plastics such as polystyrene (also known as Styrofoam), which are flammable and non-renewable. There are also non-flammable mineral-based insulation materials, as well as those made from renewable materials such as wood, hemp, or plant fibers. All of these materials contain small air-filled spaces (similar to a sweater). Since air is a poor conductor of heat, they have an insulating effect. The insulation materials are usually pressed into solid panels, attached to the outside walls, and then plastered over or sandwiched between interior and exterior walls. There are also bricks whose hollow spaces are filled with insulation. Installing insulation materials in a house costs money, but it soon pays for itself through the energy costs saved.

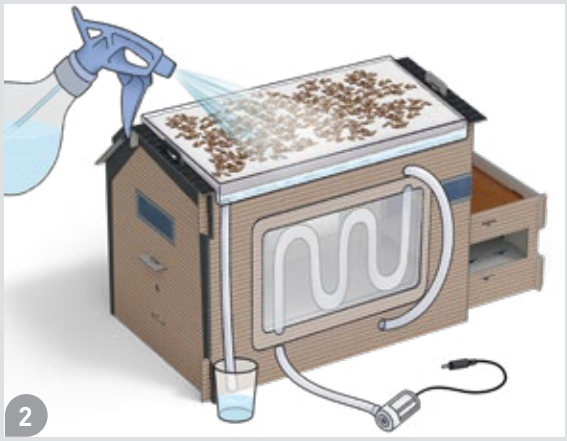
Climate Adaptation & Greening

You may have seen buildings with a green roof or facade covered in plants. In this chapter, you'll find out why this can be sustainable and counteract global warming. Building and living consume other things besides energy: water, for example, but also space and surfaces in a city. Can green roofs help counteract the consequences of this land consumption? Find out! Of course, you'll first have to put a grass roof on your own model house!

Green the roof with grass

You will need

- **Assembled model house**
- **Ryegrass seed packet**
- **Nano-adhesive pad**
- **Green roof plastic tray**
- **Cotton pad**
- *Water*
- *Spray bottle*


2

Here's how

1. Place the cotton pad in the green roof plastic tray. If you have not already, use the nano-adhesive pad to secure the tray to the roof of your house. The pad will allow you to remove the tray for cleaning and stick it back on.
2. Moisten the cotton mat using a spray bottle or by carefully pouring some water onto it. Be careful not to wet the house or the electronic parts.
3. Sow the grass seeds from the seed packet evenly on the cotton mat. Spray the seeds with water or carefully water them. Caution: The seeds can easily be washed away by too much water.
4. In order for the grass to grow, the house must be in a bright and well-ventilated place. Never let the seeds and the cotton mat dry out.
5. After a few days, the seeds should start to germinate. You can let the grass grow for one to two weeks, and even trim it back with scissors. If it dries out and turns yellow or you notice mold, throw it in the trash along with the cotton pad.

WHAT'S HAPPENING?

Your grass grows on a thin cotton pad that does not provide the grass with any nutrients. Therefore, the grass turns yellow and dries out after a few weeks. A real green roof is underlaid with many different layers, including a protective film and substrate such as pumice stone, which supplies the plants with nutrients. A green roof can include various plants, not just grass.

A green roof has many ecological advantages: For example, it offers insects and small animals a home, which is particularly useful in cities without many green spaces. Green roofs also filter dust and pollutants from the air and, at the same time, insulate from heat, cold, and noise.

TIP

YOU CAN REPEAT THE GRASS ROOF EXPERIMENT WITH YOUR OWN GRASS SEEDS (ANNUAL RYEGRASS) AND COTTON PADS FROM THE PHARMACY AS OFTEN AS YOU'D LIKE.

You will learn about another advantage in the next experiment!

EXPERIMENT 9: COLLECTING WATER

Rainwater runoff

You will need

- **Assembled model house**
- **Green roof with grass**
- **Measuring cup "rain barrel"**
- *Water*
- *Cup*
- *Stopwatch or cell phone*

Here's how

1. Measure 50 ml of water with your measuring cup and pour it into a cup.
2. Make sure the silicone tube is connected to the gutter and inserted into the measuring cup at the bottom (figure 5).
3. Have a stopwatch or a mobile phone with a stopwatch function ready.
4. Pour the 50 ml of water slowly onto the grass covering of the roof and start the stopwatch.
5. After 30 seconds, measure how much water has arrived in your "rain barrel" (the measuring cup).
6. Repeat this experiment without the grass and the cotton mat. To do this, take them out of the plastic tray. How many milliliters of water pour into the measuring cup in 30 seconds this time?

5

WHAT'S HAPPENING?

In the first experiment, less water ends up in the measuring cup than in the second experiment without the grass. Some of the water is fully absorbed by the grass and the cotton mat, and the rest flows more slowly.
In this experiment, the water that you put on the grass or the plastic tray represents the rain that falls on house roofs. Rain that falls on a green roof is held back and flows more slowly. This prevents streets and sewers from being flooded by too much water in too short a time, especially during heavy rainfall. In regions where climate change is causing heavier rainfall, green surfaces can mitigate potential flooding.

CHECK IT OUT

Housing forms AND THEIR EFFECT

Multi-level apartments with greened roofs

Large areas of the Earth's surface are sealed — for example by roads, buildings or large paved squares. Rainwater cannot seep into the ground and replenish the groundwater. At the same time, more and more housing is needed for people, especially in growing cities. This is why multi-story apartment buildings are often built, which cover less land per living space than single-family homes. On the other end of the spectrum, the "tiny houses" that are popular in some places have advantages and disadvantages: on the one hand, they do not take up as much space as single-family homes, but on the other hand, they are usually built on existing green spaces and only inhabited by one or two people.

Urban Green Space

Even a single family house benefits from having a green roof. In cities, however, greening with trees, parks, or green roofs is even more important. This is because trees and green spaces improve the **microclimate** — the climatic conditions of their immediate surroundings. Green spaces cast shade, filter dust from the air, and evaporate water. Overall, they reduce temperatures in their immediate surroundings by up to eight degrees Celsius — particularly important in light of climate change in areas where it's getting warmer!

A Second Life for Your Model House

Have you ever wondered what happens to the building materials and all the technology from demolished houses? In this chapter you will learn why so-called recycling and upcycling can also be useful and important for building materials. Of course, this also applies to your model house: When you have finished all the experiments and no longer need it as an experimental model, you will find great upcycling ideas for individual parts of your house here.

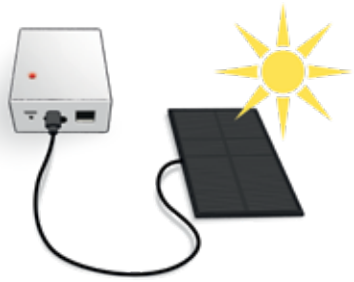
Upcycling ideas for your house

You will need

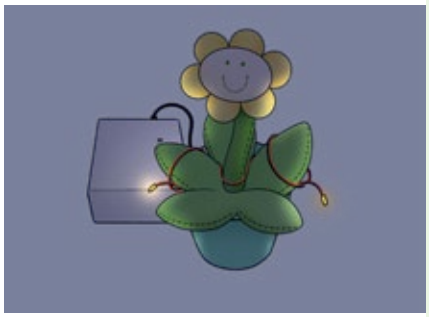
- **The model house**
- *Depending on the project: Craft materials such as tracing paper, construction paper, acrylic paint, adhesive tape, craft glue, scissors, pen, seeds for microgreens (e.g. cress), toy figures, modeling clay, LED tea light, cotton wool*

Ideas for ..

... the battery station and solar cell:
If you remove the battery station and the solar cell from the house, you can use them as a solar battery charger. Place the solar cell in the sun and use it to charge batteries that you need for a flashlight, robot, or other device.
Important: Only rechargeable batteries of type HR06 (AA, NiMH) may be placed in the compartment. Have an adult help you with this.



... the LED set:
Together with the battery station, you can use the two LEDs as small night lights. Decorate an object with them or place them inside a small lantern. As soon as the room gets dark, the two LEDs will start to light up.



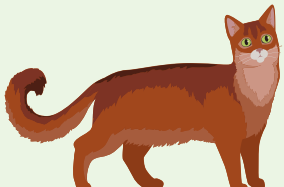
... the water pump:
Build a small indoor fountain with the water pump! To do this, you need a container and, of course, the hose and the battery compartment. Build a fountain figure and thread the hose leading away from the pump through it so that the water flows back into the container.
Important: The pump may only be operated with water. Protect the battery compartment and the surrounding area from moisture. When not in use, allow the water pump, hose, and container to dry thoroughly.

...the house itself:
Convert the house into a lantern or lamp: Paint the outside of the house in an opaque color of your choice. If you want, cover the windows and the transparent climate control module with colored tracing paper. Now you can light up the house with the LED set or put an electric lantern inside. If you want the LED set to always light up when it is plugged in (and not just in dark rooms), cover the light sensor with a piece of opaque tape.

... the mower bot:
Scare friends and family by turning the mower bot into an insect, scorpion, or other scary animal! Glue or attach a paper printout or toy figure to the robot. Charge it secretly from the battery compartment and then let it go.

... the plastic tray:
In the plastic tray, you can grow cress or other microgreens — the sprouts of young vegetable plants — on cotton wool. To harvest, cut them off above the cotton wool using clean kitchen scissors.
Important: Remove all grass and cotton pad residue and clean the tray carefully before replanting. If mold forms, please dispose of the cotton wool and the germinated plants. Clean the tray and replant if necessary. Harvested plants can either be eaten immediately or stored in the refrigerator for a maximum of 1 to 2 days.

Wow!
so many ideas!



Can buildings be recycled?

When a building has to be demolished, a lot of rubble is produced. This material, which accounts for around a quarter of all waste in the United States alone, is usually dumped in landfills or used as gravel in road construction. However, rubble contains many valuable raw materials such as wood, glass or aluminum. This is why attempts are now being made to recycle building materials such as concrete. Old concrete is ground into small granules to reuse. New houses can also be designed so that their components can later be easily separated and reused.

Earthships ...

... are a special form of sustainable building and living. These houses, designed by the architect Michael Reynolds in the 1970s, are built largely from recycled waste materials such as tires, bottles or cans and plastered with clay. The so-called Earthships produce their own electricity using a solar system. Like passive houses, they do not need to be heated, as they maintain their temperature in summer and winter solely through solar radiation through large windows, geothermal energy, and good insulation. The house also processes rainwater and feeds it into its own water cycle.

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Manual photos: Jaimie Duplass & beror (alle Klebestreifen, ©fotolia); user6702303, p.17 ml, freepik.ctm; AS_ Photographics, p.16tr; Bru-nO, p.12mt; Hans, p.18tr; longdan91, p.23tr; momentmal, p.32tl (all ©pixabay.com); Alexandru Chiriac, p. 16/17 b; AndriiKoval, p. 18mr, p.24tl; aslysun, p.17br; Aquir, p.25mr; Bilanol, p.24mr; FamVeld, S25tm; Halfpoint, p. 1b, 12ml; INTREEGUE Photography, p.28tr; jittawit21, p.12mt; Johannes Ricardo Abbas, p. 11b; Kidzkamba, p.13mr; Lucy, p.32mr; Maria-Cezara Panaite, p.10tr; panyajampatong, p.29 mt; rawpixel by freepik, p.11 mr; Ralf Geithe, p.16 lb; Rene Notenbomer, p. 28 br; Sharomka, p.20tl; Smileus, p.17tr; Snapshot freddy, p.23mr; stockcreations, p.24bl; Sunflowerey, p.28ml; U. J. Alexander, p.23ml; VectorMine, p.20 br (all ©shutterstock.com);Daniel Krienbuehl, p.21 mr, www.dkcontractors.biz/passivesolar-design.html; inside cover (kit contents), Matthias Kaiser, Zuckerfabrik, Stuttgart

Design concept and packaging design: Peter Schmidt Group, Hamburg
Packaging, sticker, and film design: Joanna Mühlbauer, Steingaden
Seed packet layout: Mariela Schwerdt, Stuttgart
House design and 3D images for packaging and manual: Andreas Resch, St. Ulrich am Waasen

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Phone: 800-587-2872; Web: www.thamesandkosmos.com

Distributed in the UK by Thames & Kosmos UK LP. Cranbrook, Kent TN17 3HE.
Phone: 01580 713000; Web: www.thamesandkosmos.co.uk

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Printed in Germany / Imprimé en Allemagne.

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627931-03-140125