

EXPERIMENT MANUAL

# Wind Power

**Build a wind turbine to generate electricity!**



THAMES & KOSMOS

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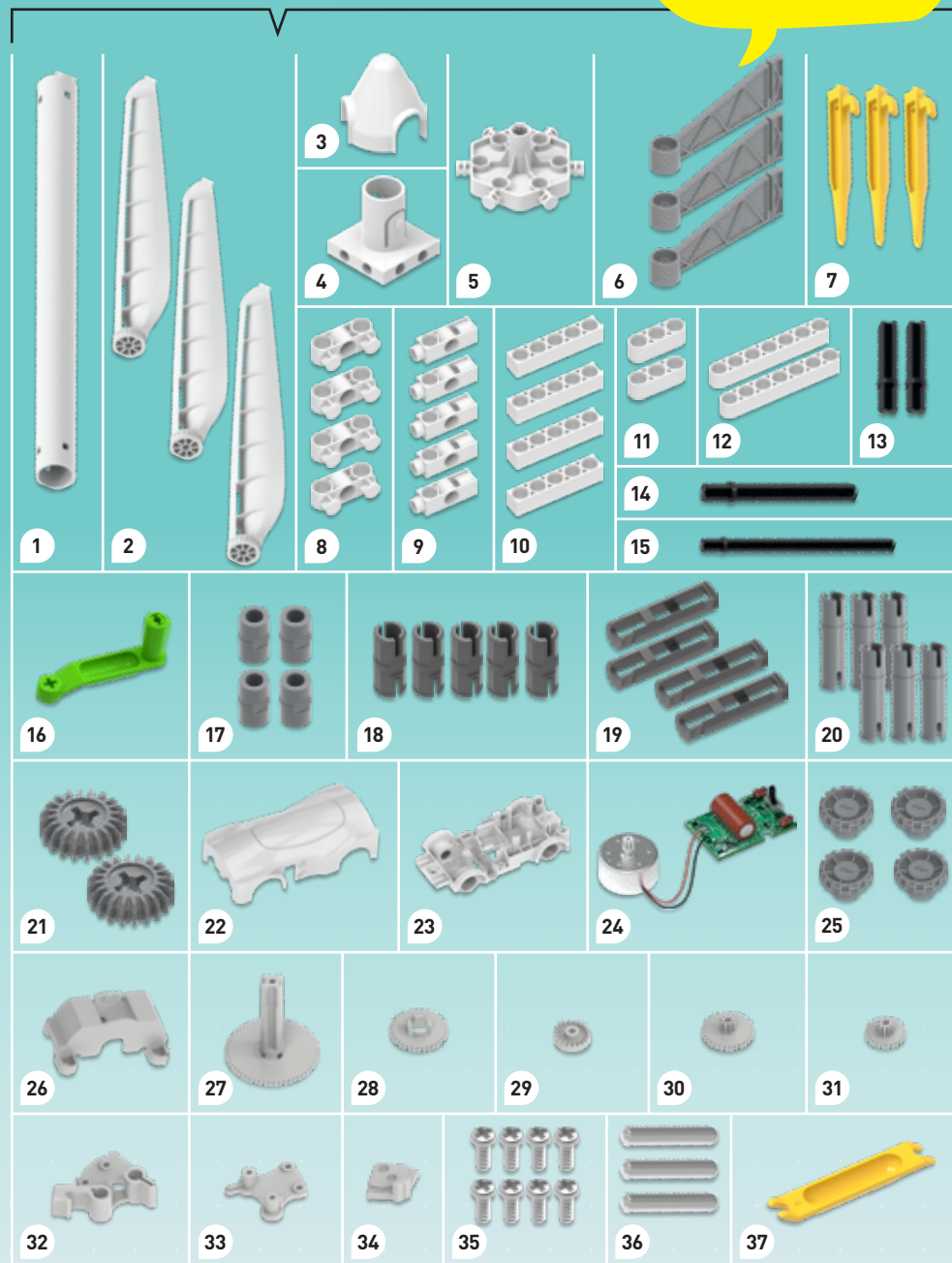


## KIT CONTENTS

*Good to know!*

If you are missing any parts, please contact Thames & Kosmos customer service.

What's in your experiment kit:



**CONTENTS**

Kit Contents .....	Inside front cover
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## ASSEMBLY INSTRUCTIONS BEGIN ON PAGE 4

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**TIP**

YOU WILL FIND  
ADDITIONAL INFORMATION IN  
THE CHECK IT OUT SECTIONS ON  
PAGES 18-20, 24, AND 30.

**TIP**

YOU CAN FIND A BRIEF  
GUIDE TO OPERATING THE  
ASSEMBLED WIND TURBINE  
ON PAGES 31 AND 32.

**YOU WILL ALSO NEED:**

*Small Phillips-head screwdriver,  
compass, computer or smart  
device, scissors, paper, pen,  
cling wrap*

*Woohoo!*

Let's go!

**Checklist:**

✓ No.	Description	Quantity	Item No.	✓ No.	Description	Quantity	Item No.
○ 1	Tower	1	716028	○ 19	Long anchor pin	4	725251
○ 2	Rotor blade	3	722773	○ 20	Long joint pin	6	721344
○ 3	Nose cone	1	716037	○ 21	Small gear	2	722353
○ 4	Tower connector	1	716029	○ 22	Car body	1	729443
○ 5	Rotor blade hub	1	716038	○ 23	Car chassis	1	729433
○ 6	Foot	3	722774	○ 24	Motor with circuit board	1	729444
○ 7	Stake	3	729432	○ 25	Wheel	4	729447
○ 8	3-hole adapter	4	715681	○ 26	Gearbox cover	1	729448
○ 9	3-hole dual rod	5	714283	○ 27	Gear with axle	1	729434
○ 10	5-hole rod	4	716875	○ 28	Slip-on gear	1	729439
○ 11	3-hole wide rounded rod	2	715683	○ 29	Crown gear	1	729440
○ 12	7-hole wide rounded rod	2	715684	○ 30	Double gear, large	1	729442
○ 13	35 mm axle	2	716861	○ 31	Double gear, small	1	724223
○ 14	60 mm axle	1	718278	○ 32	Gear housing A	1	729445
○ 15	100 mm axle	1	703234	○ 33	Gear housing B	1	729435
○ 16	Hand crank	1	729446	○ 34	Switch	1	729441
○ 17	Short anchor pin	4	722517	○ 35	Screw	8	724224
○ 18	Joint pin	5	725243	○ 36	Metal axle	3	724226
				○ 37	Part separator tool	1	702590



### WARNING!

Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled.

**Warning:** This toy is only intended for use by children over the age of 8 years, due to accessible electronic components. Instructions for parents or caregivers are included and must be followed. Keep the packaging and instructions as they contain important information.

May only be operated when fully assembled. Proper assembly must be checked by an adult before use.

## Notes on Disposal of Electric 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 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.

→ Before beginning the experiments, read through the instructions along with your child, discuss the safety notes, and keep them on hand for reference. Check to make sure that the models have been assembled properly, and be ready to help with the experiments.

→ The wind turbine is suitable for indoor and outdoor use with the right amount of airflow. A scale for measuring wind speed, called the Beaufort scale, is given on page 20. To ensure that the turbine works properly, the wind force should be at least 2, but not more than 4, because the turbine could be damaged if the wind is too strong. Indoors, you can simulate wind with the help of a powerful electric fan.

→ Even though the wind turbine model is water resistant and can be used outdoors, it must be protected from the weather (mainly rain and frost), so that there is no damage to the electrical system and the other components. Therefore, it is best to bring it inside after every experiment. You can clean all the external parts with a wet cloth; do not use soap or any detergent-based products for this.

We hope you and your child enjoy experimenting while learning about the technology behind clean energy and all of its benefits!

*Have  
fun!*



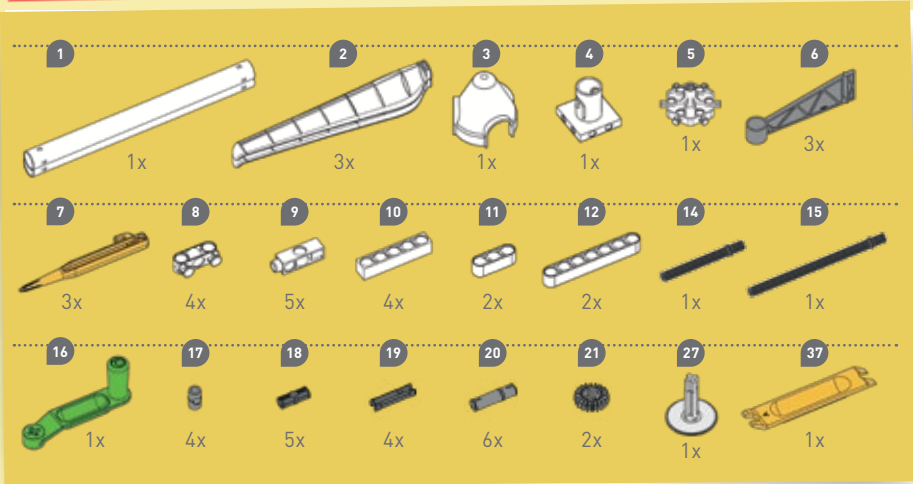
# Assembling YOUR WIND TURBINE



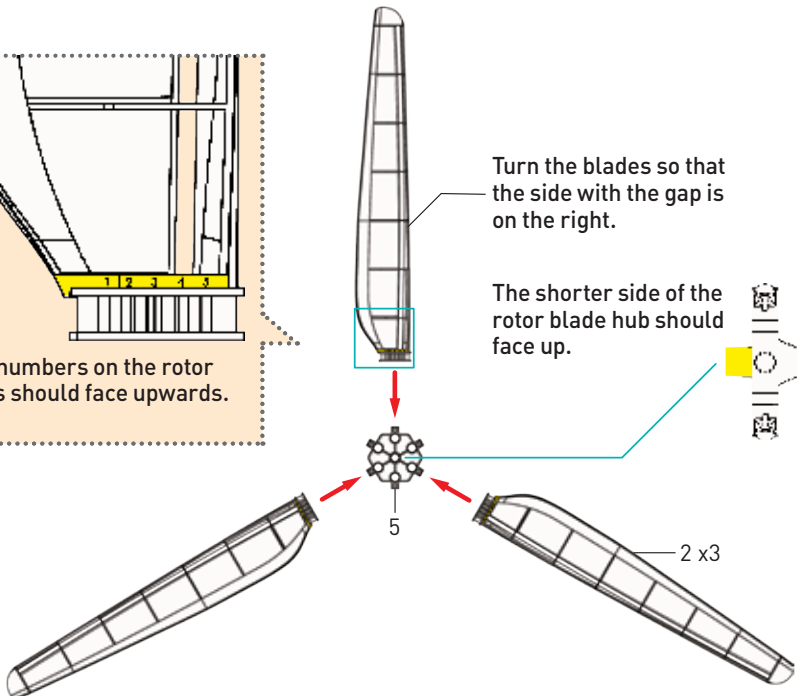
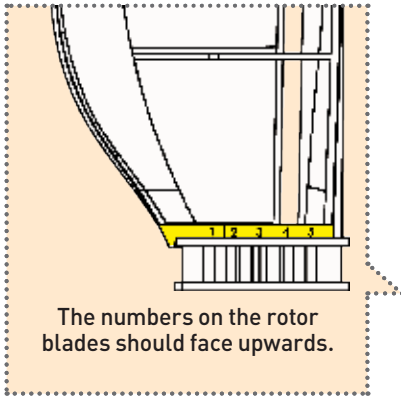
People have been building wind turbines for centuries to harness the power of the wind. Windmills convert the kinetic energy of the wind into rotary motion. In the past, they were used to grind grain, but today they are used to generate electricity. And now it's your turn to build one.



## ASSEMBLING THE WIND TURBINE

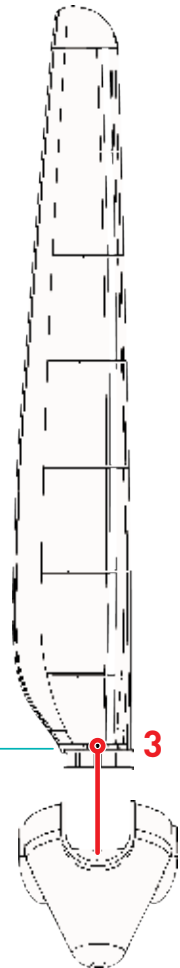
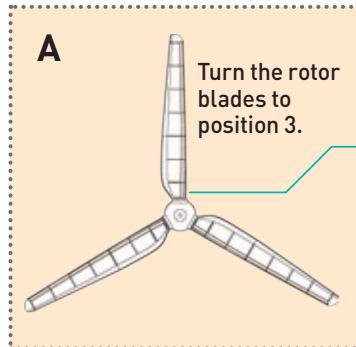
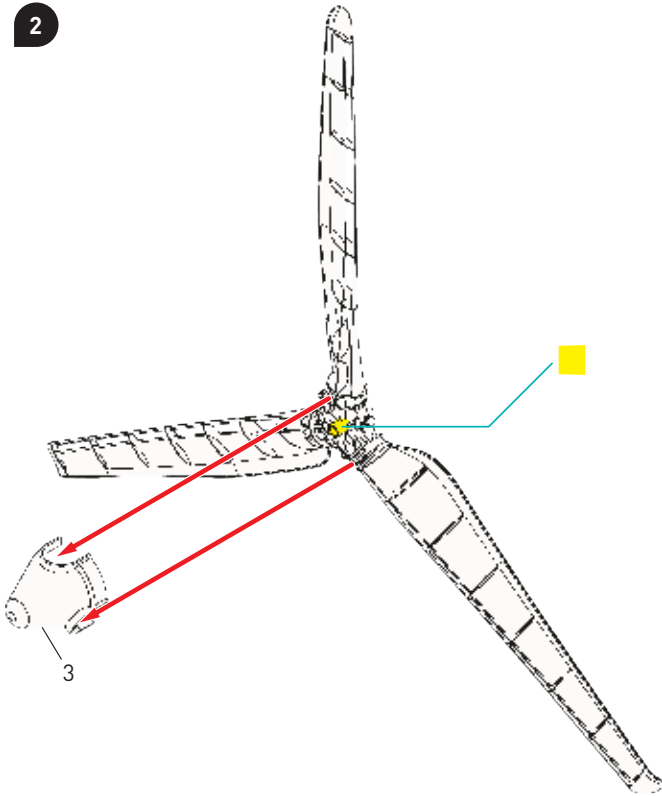


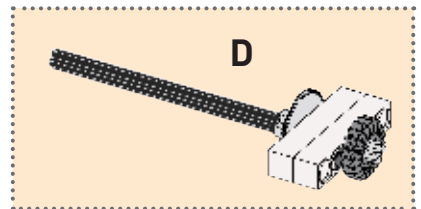
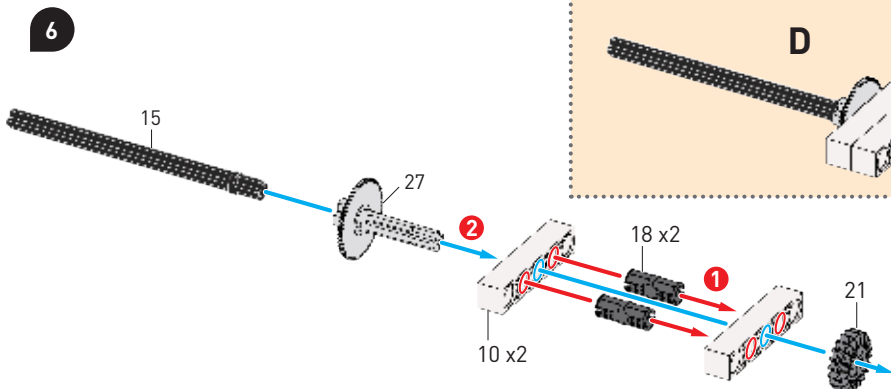
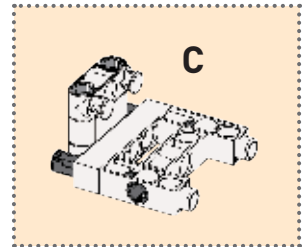
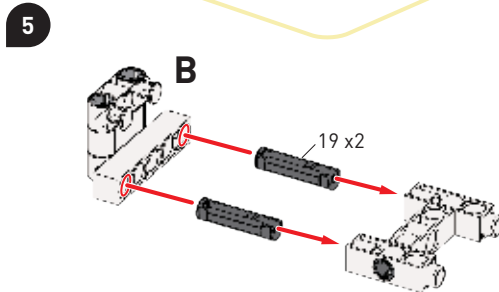
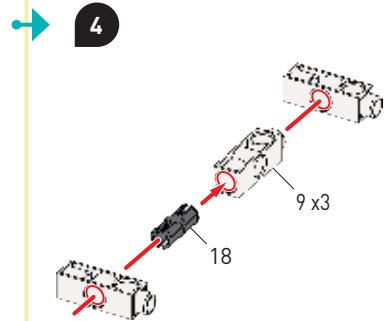
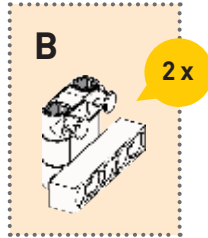
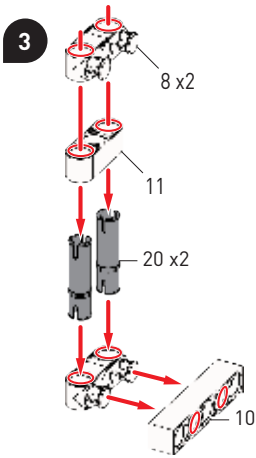
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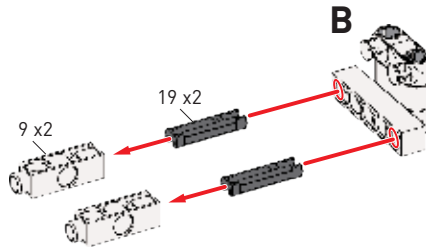




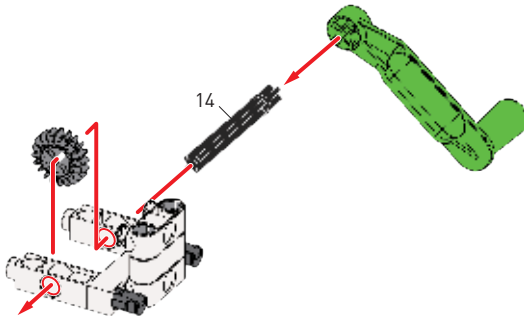




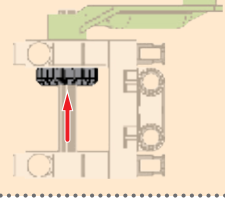
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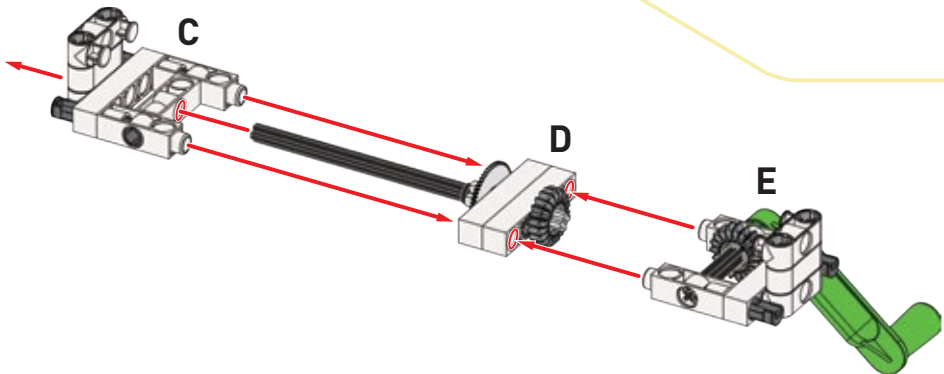
Press the flat side of the gear against the side where the crank is.

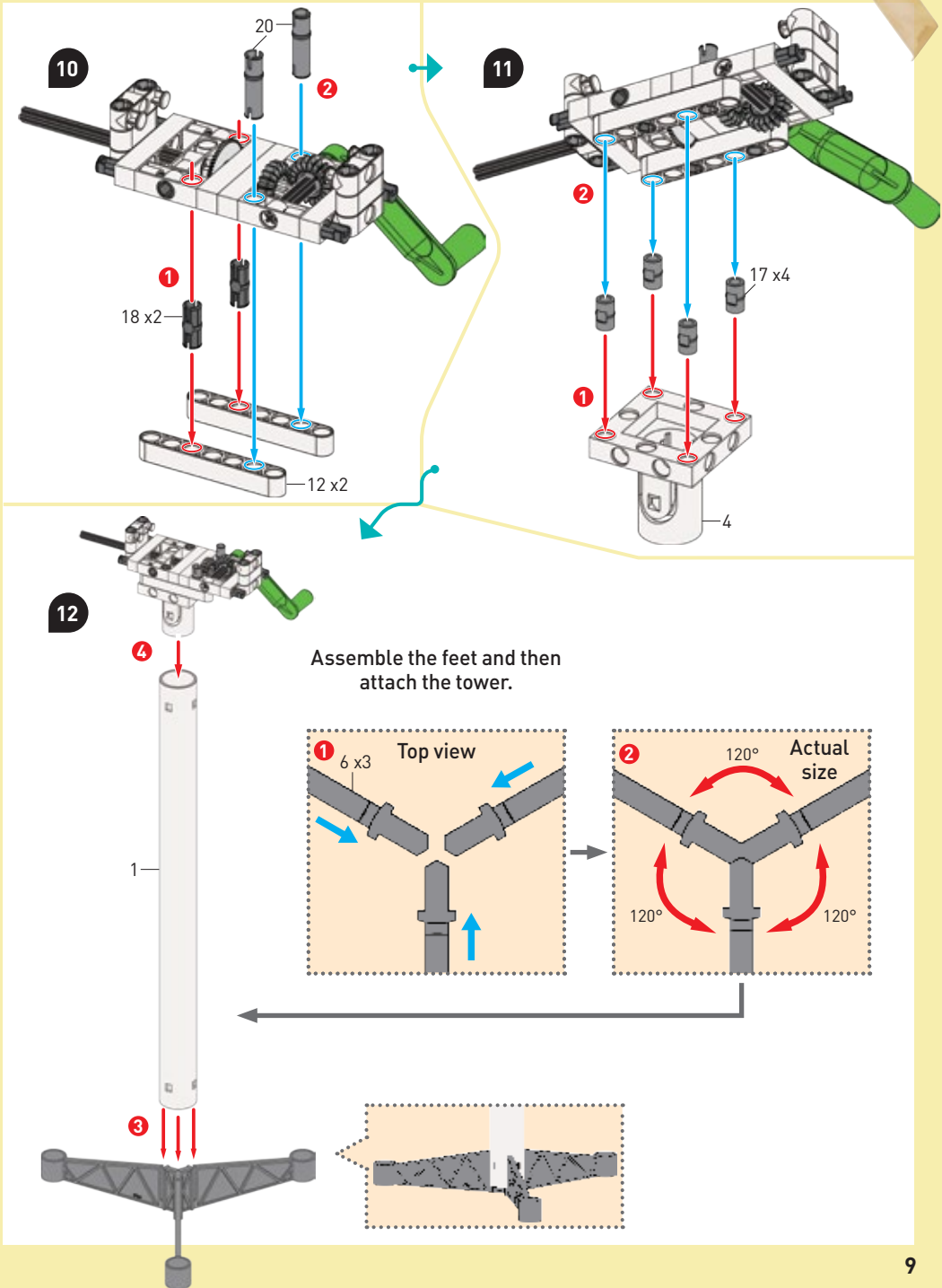


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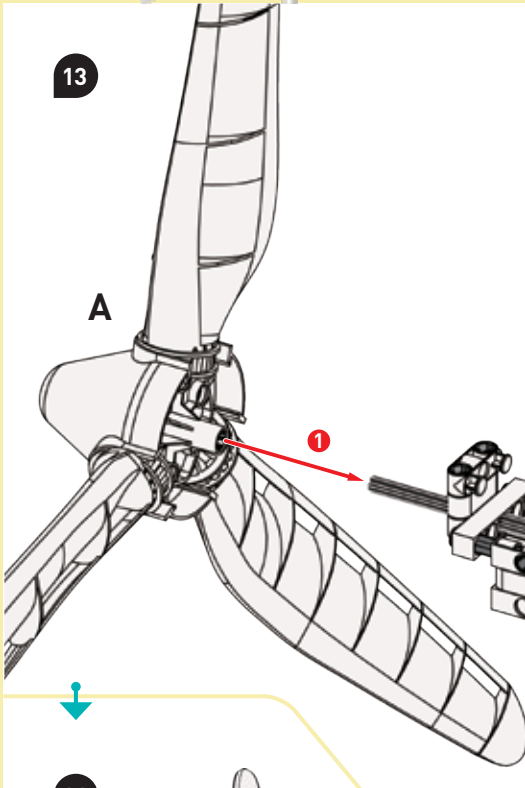




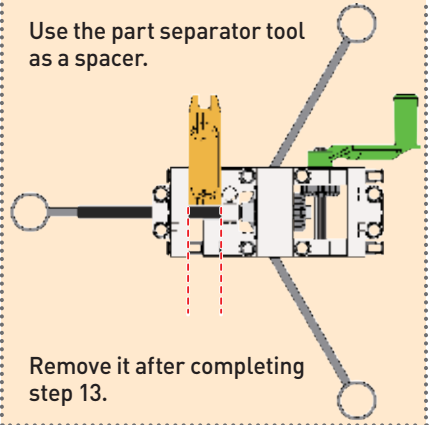


13

A

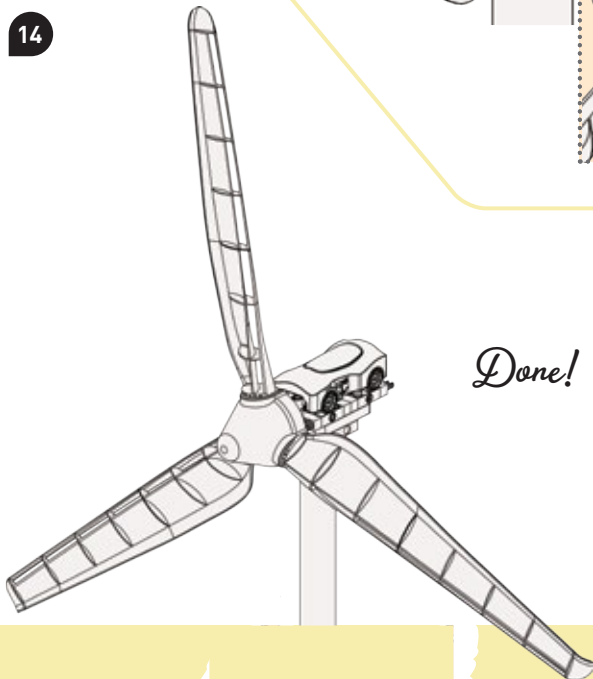
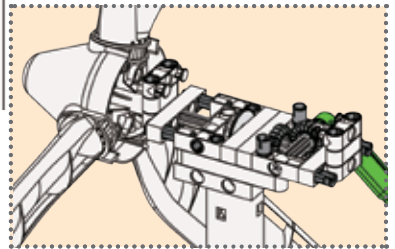


Use the part separator tool as a spacer.



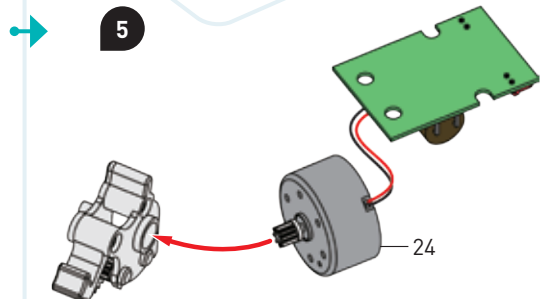
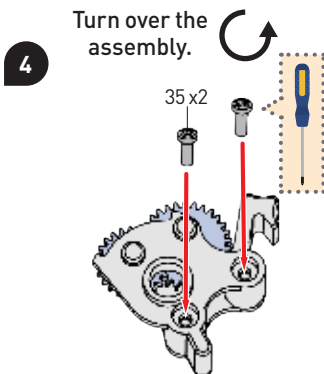
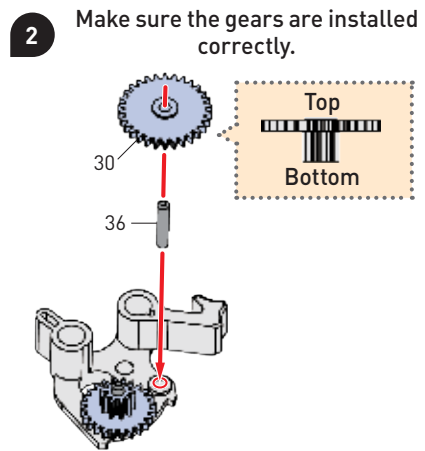
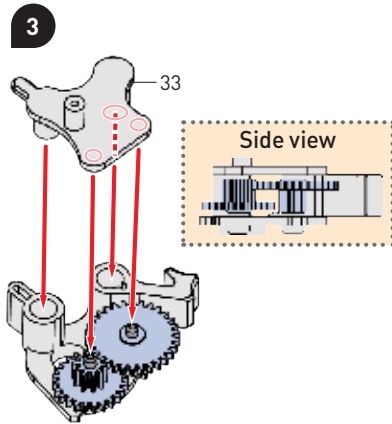
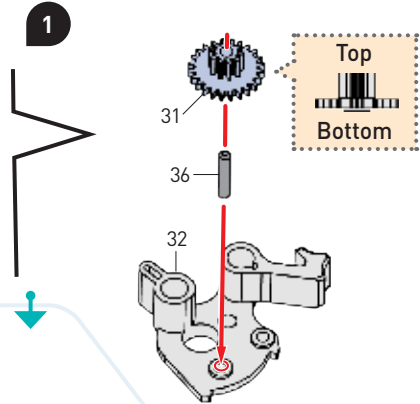
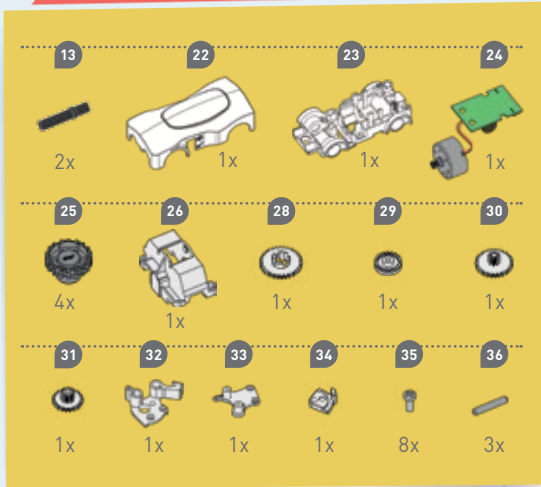
Remove it after completing step 13.

14



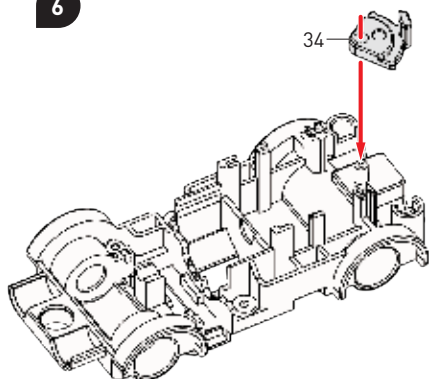
*Done!*

# ASSEMBLING THE CAR



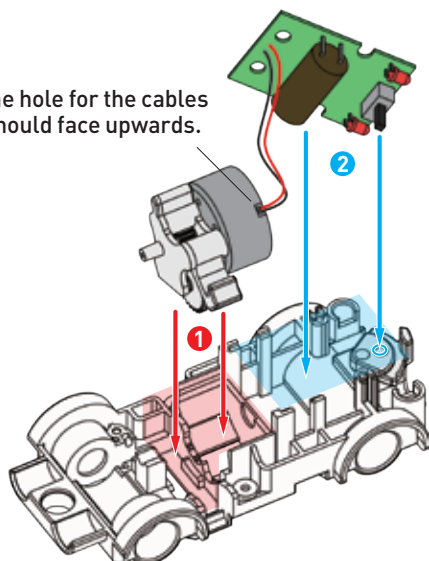


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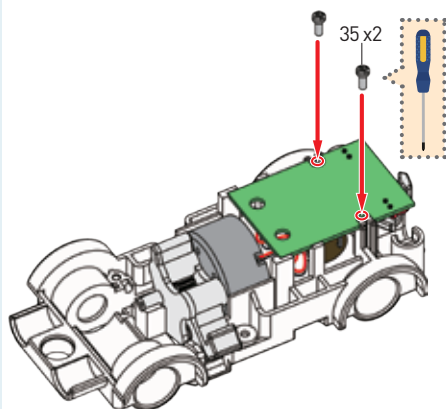


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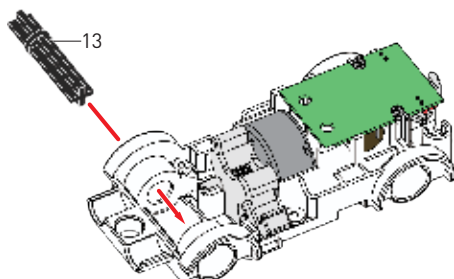
The hole for the cables should face upwards.



8

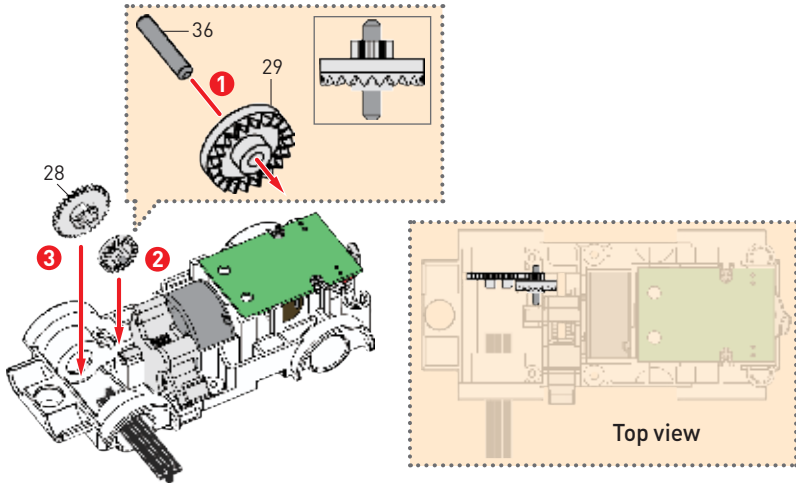


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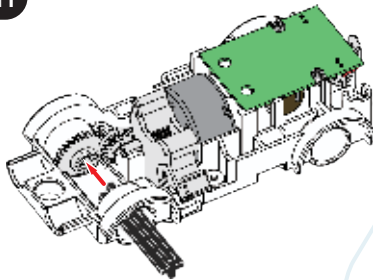




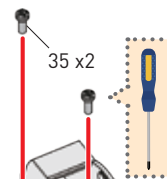
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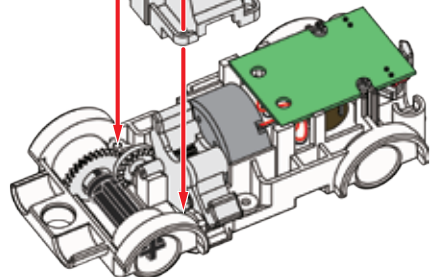
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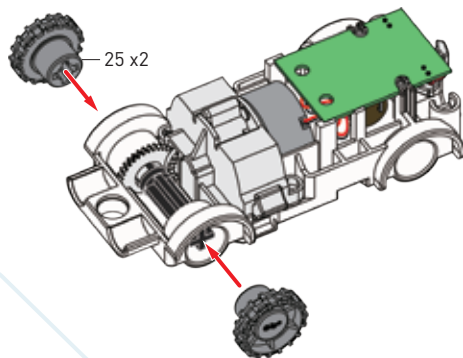
Tighten the screws securely.



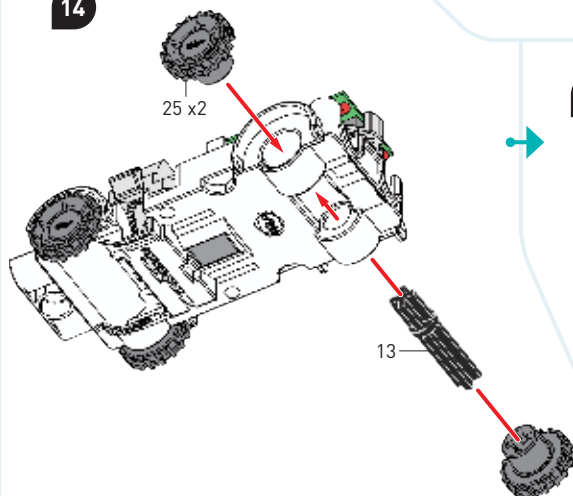
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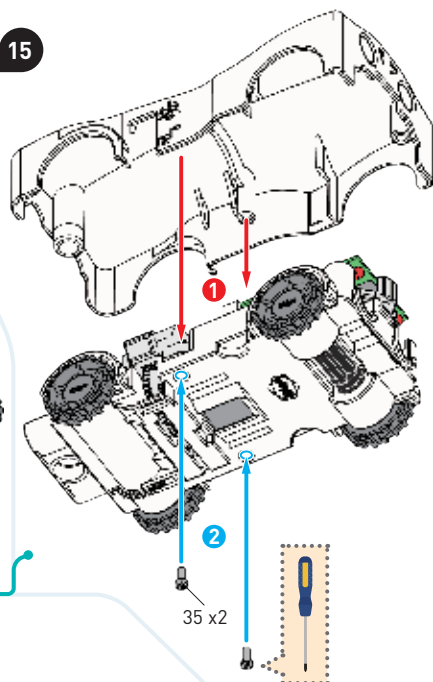
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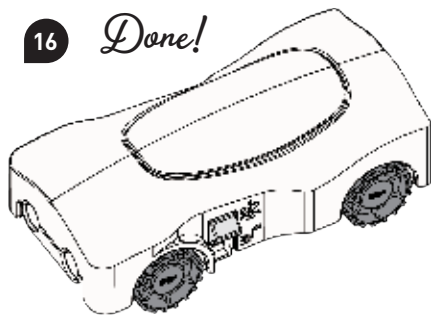
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15



16

*Done!*

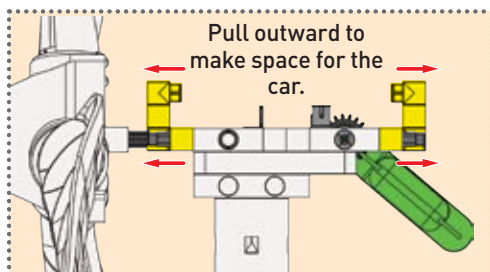
## WHAT'S HAPPENING?

The nacelle of your wind turbine is also an electric car. It contains an electric motor that also functions as a generator and a power storage unit. You can find more information about this technology on page 24.

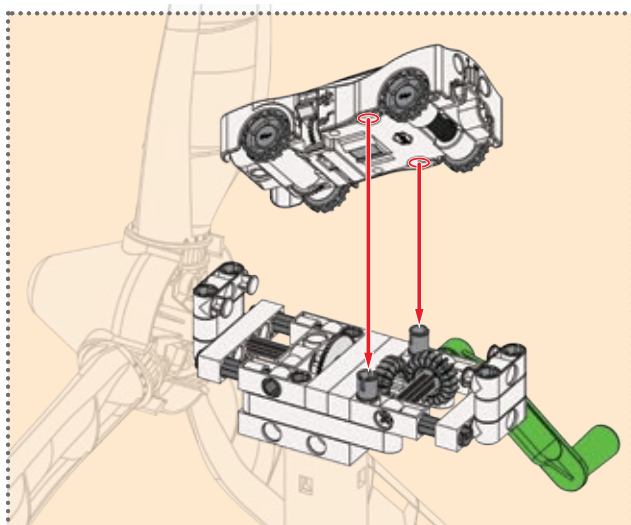


## MOUNTING THE CAR ON THE WIND TURBINE

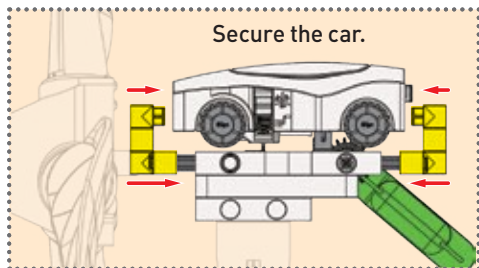
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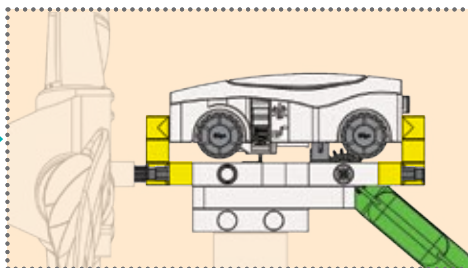
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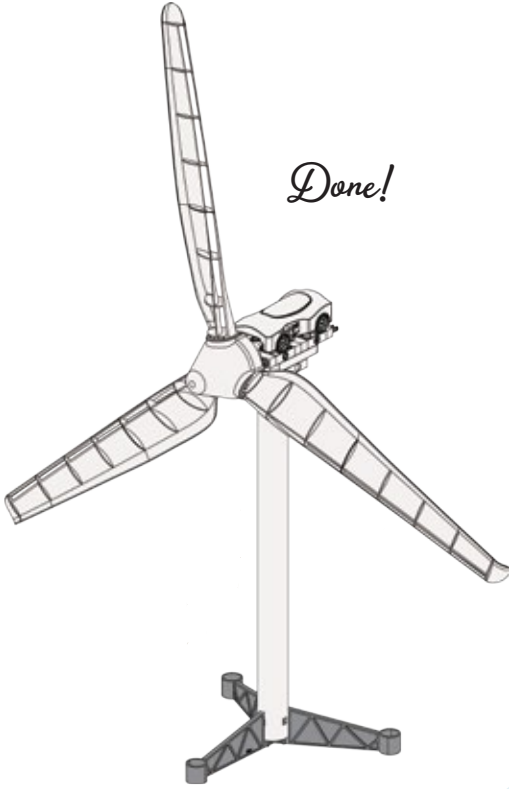


4





*Done!*

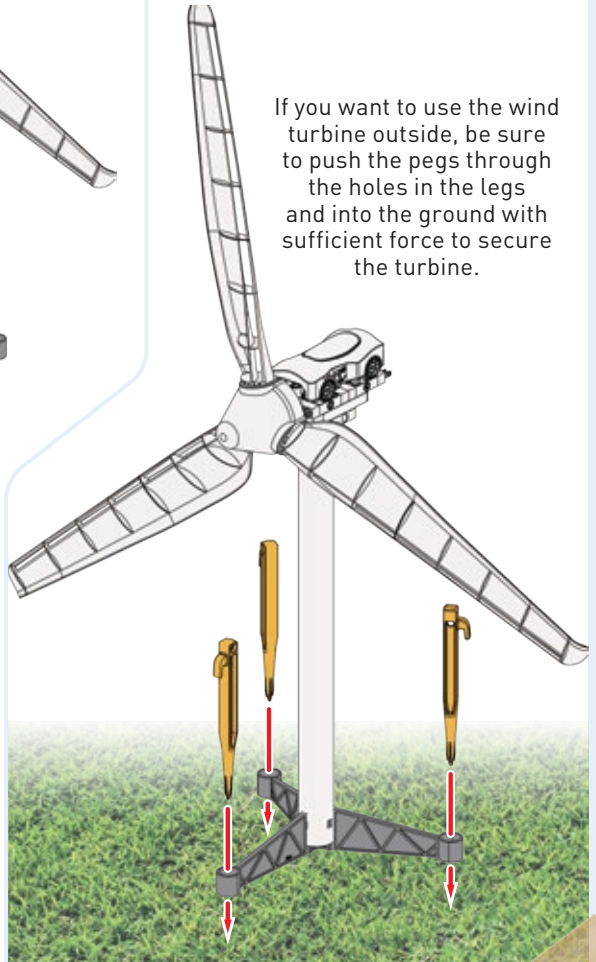


If you want to use the wind turbine outside, be sure to push the pegs through the holes in the legs and into the ground with sufficient force to secure the turbine.



**TIP**

A BRIEF GUIDE ON HOW  
TO OPERATE AND  
CORRECTLY SET THE  
SWITCHES CAN BE FOUND  
ON PAGES 31 AND 32.



**EXPERIMENT 1**

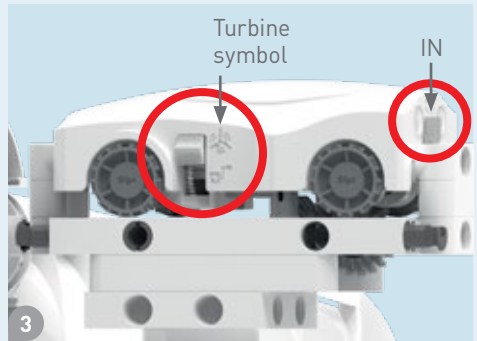
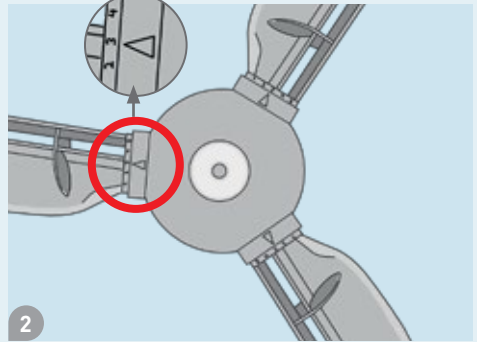
## Faster than the wind

### You will need

- Wind turbine
- Car

### Here's how

1. Take the turbine outside to an open, flat area. A field or a basketball court are good options. If you've chosen a windy day, skip right to Experiment 4.
2. Set the rotor blades to position 3.
3. Set the switch on the side of the car to the turbine symbol. Set the switch on the back of the car to IN.
4. Hold the wind turbine in front of you with your arm outstretched and run. Be sure that the wind isn't blowing from behind you.



### **WHAT'S HAPPENING?**

When the air around you is still and you move quickly, you create a **headwind**. In reality, it's not wind because it's you, not the air, that is moving. But the effect is similar: Your wind turbine starts to spin.





## CHECK IT OUT

# How the wind turns the turbine

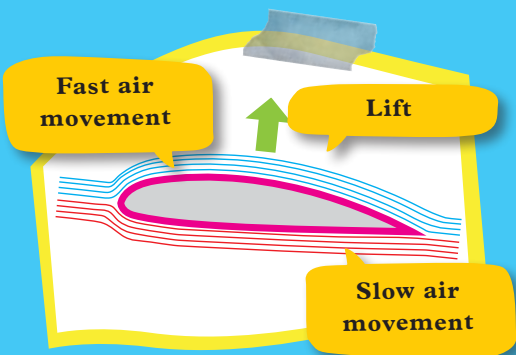
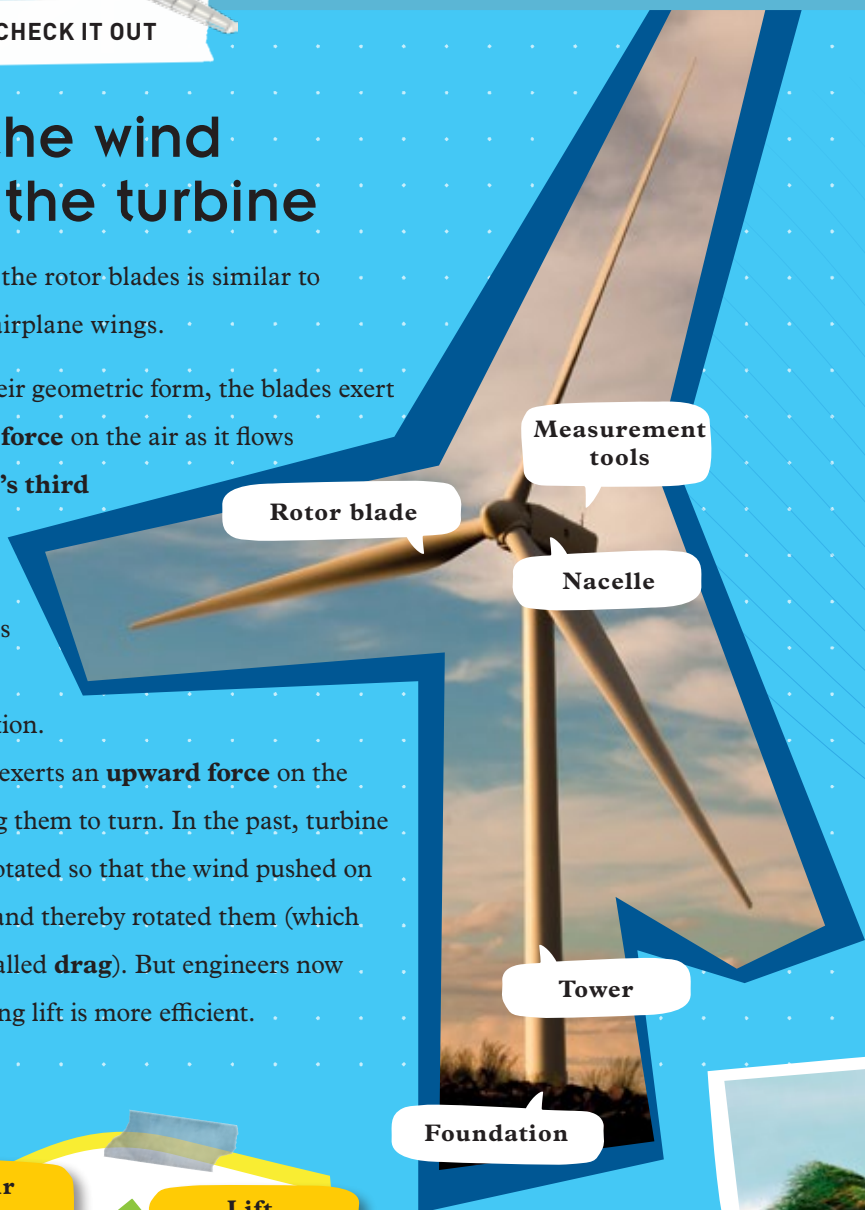
The shape of the rotor blades is similar to the shape of airplane wings.

Because of their geometric form, the blades exert a **downward force** on the air as it flows

past. **Newton's third**

**law** states that for every action, there is an equal and opposite reaction.

Thus, the air exerts an **upward force** on the blades causing them to turn. In the past, turbine blades were rotated so that the wind pushed on their surface and thereby rotated them (which uses a force called **drag**). But engineers now know that using lift is more efficient.





# Wind

Wind is air that moves. But how exactly does air get moving?



The engine that drives the wind is the sun. When the sun shines on the earth, the air on the ground warms up and rises. To prevent an empty space from forming above the ground, cold air flows in. We experience this flow as wind.

## BEAUFORT SCALE

For wind turbines, and also for our everyday lives, it is sometimes important to know how strongly the wind will blow. To standardize this information, institutions such as the National Weather Service use the Beaufort scale, which was originally developed for sailing ships in the British Royal Navy in the 1800s. You can see all the details of the scale on the next page.





# The Beaufort Scale

Beaufort Number	Wind Speed mph                  m/s		Description	Effect
0	<1	<0.3	Calm	No air movement, smoke rises vertically.
1	1-3	0.3-1.6	Light air	Smoke drifts slightly, but wind vanes do not move.
2	4-7	1.6-3.4	Light breeze	Smoke moves obviously in the direction of the wind. Leaves rustle and breeze can be felt on face.
3	8-12	3.4-5.5	Gentle breeze	Small twigs move; light pennants and small flags extend.
4	13-18	5.5-8.0	Moderate breeze	Small branches move; dust and loose paper blow around.
5	19-24	8.0-10.8	Fresh breeze	Small trees in leaf sway; the wind can be clearly heard. Lakes form wavelets.
6	25-31	10.8-13.9	Strong breeze	Large branches sway; umbrellas become difficult to use. Telephone wires whistle.
7	32-38	13.9-17.2	Moderate gale, near gale	Whole trees sway and it becomes inconvenient to walk into the wind.
8	39-46	17.2-20.8	Gale, fresh gale	Large trees sway; twigs and leaves break off trees; walking becomes difficult.
9	47-54	20.8-24.5	Strong/severe gale	Branches break; shingles are blown off roofs.
10	55-63	24.5-28.5	Storm, whole gale	Trees break or are uprooted; garden furniture is blown away; houses are damaged.
11	64-72	28.5-32.7	Violent storm	Severe damage to forests. Roofs are blown off. Cars are thrown off the road. Thick walls are damaged.
12	>73	>32.7	Hurricane force	Severe storm damage and devastation, especially near the sea.



# Electro-mobility



The energy that is generated from wind power can be used, for example, to charge the batteries of electric cars. Electric cars are only truly emission-free if the electricity used to charge them is generated from renewable energies. If oil or gas is burned to generate the electricity, they are still responsible for CO<sub>2</sub> emissions — from the power plant, rather than the car.

## EXPERIMENT 2

# Electricity from muscle power

### You will need

- Wind turbine
- Car

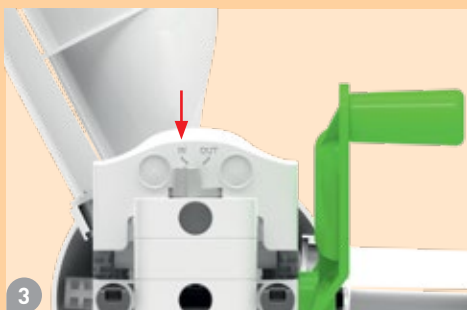
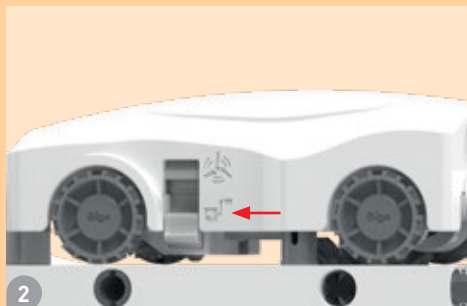
### Here's how

1. Mount the car on the wind turbine.
2. Set the switch on the side to the position with the hand crank symbol.
3. Set the switch on the back to IN.
4. Check that the wind turbine can turn freely without hitting anything.
5. Turn the crank to the right, following the direction of the arrow on the car.



### TIP

IF IT JUDDERS AND  
MAKES A STRANGE SOUND,  
REFER TO THE  
TROUBLESHOOTING TIPS  
ON PAGE 32.



### WHAT'S HAPPENING?

If you crank for long enough, the light on the back of the car will begin to glow, indicating the capacitor is charged. There are ways to convert one type of energy into another. In this case, you're transforming kinetic energy into electrical energy.



**EXPERIMENT 3**

## Your electric car

### You will need

- Charged car

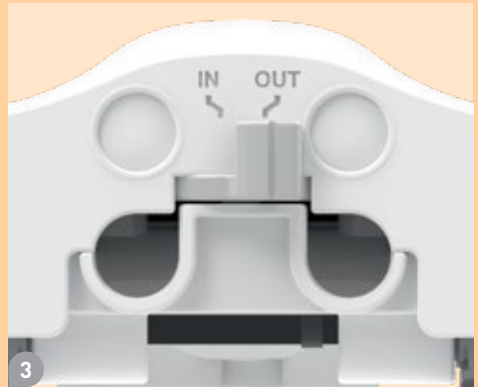
### Here's how

1. Remove the car from the turbine.
2. Make sure that the switch on the side is still in the hand crank position.
3. Set the switch on the back to OUT and put the car on a clean, flat floor.
4. Watch the car move forward slowly. The electricity powering this car was generated by your hand turning the crank in Experiment 2!



### TIP

**YOUR CAR GOES FASTER  
WHEN YOU CHARGE IT  
LONGER. IF IT DOESN'T  
MOVE, REFER TO THE  
TROUBLESHOOTING TIPS  
ON PAGE 32.**



### WHAT'S HAPPENING?

In Experiment 2, you converted kinetic energy into electrical energy. In this experiment, you do the exact opposite: the stored electrical energy is used to make the car move.



## CHECK IT OUT

# MOTOR OR GENERATOR?

You can probably imagine that the motor is used to drive your electric car and consumes electricity in the process. To be more precise, the motor converts electrical energy into kinetic energy.

A generator works in exactly the opposite way. A generator is used to generate electricity. This means that when the wind turbine rotates, the generator converts kinetic energy into electrical energy. Motors and generators both use electromagnetic induction to convert energy from one form to another.

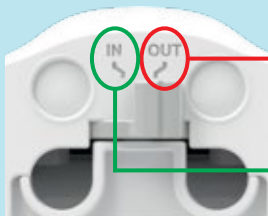
Part 24 is the heart of your wind turbine. It consists of an electric motor that is connected to a circuit board via two cables.

## AND WHERE IS THE GENERATOR?

The cool thing about electric motors is that they can also be used as generators.

The only difference is in the way the component is used:

- If electricity flows through the component, it is a motor. The electricity rotates the axle.
- If the axle is rotated manually — i.e. by the hand crank or by wind — it is a generator. Electrical energy is generated.



**OUT: Motor mode**  
Electricity flows **OUT** of the capacitor

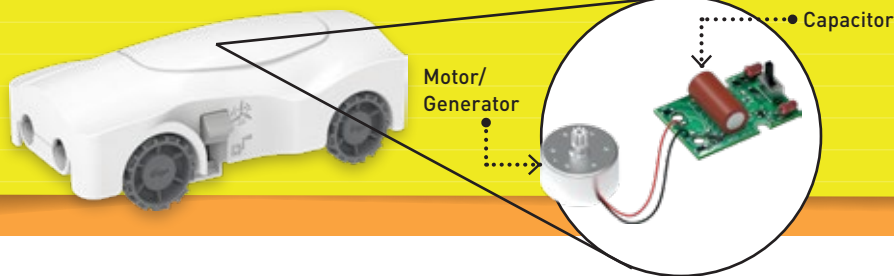
**IN: Generator mode**  
Electricity flows **IN** to the capacitor

## Where does the power go?

You've probably noticed that this wind turbine doesn't have any batteries. So where does the power that it generates go?

Attached to the circuit board, you'll find an interesting red part. This is where the energy is stored.

However, it's not a battery, it's a **capacitor**. Like a rechargeable battery, a capacitor can store energy as well as expend it. The advantage of a rechargeable battery is that it can store significantly more energy. However, a capacitor can absorb and release energy much more quickly.





*Warning:*  
Do not use  
during  
a storm!

# USiNG Wind

Wind carries an enormous amount of energy. Maybe you've noticed this when you're walking or riding your bike and you get blown off course. To use this energy as efficiently as possible, it's important to keep a few things in mind. And if the wind is too strong, it can destroy wind turbines.

## EXPERIMENT 4

# Wind power

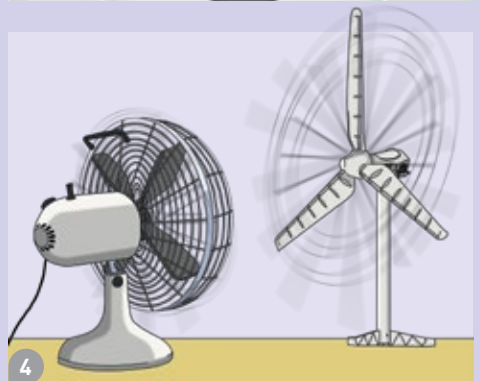
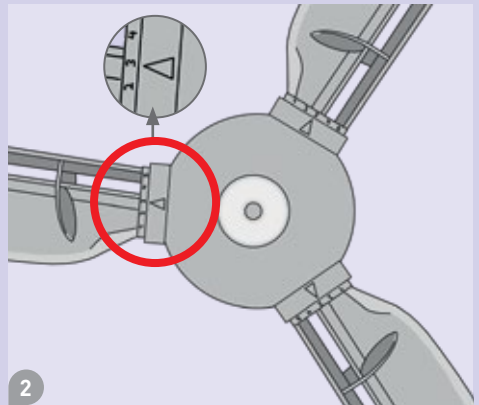
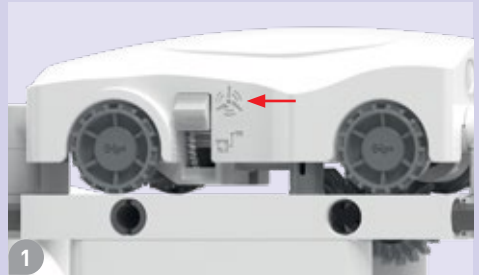
### You will need

- Wind turbine
- Car
- Stakes *or* fan

### Here's how

1. Set the switch on the side of the car to the wind turbine position.
2. Set all the rotor blades to position 3.
3. Set the switch at the back of the car to IN. The energy generated will now flow into the capacitor (inside the car) and be stored there.
4. **Outdoors:** In wind conditions between 2 and 4 on the Beaufort scale (see p. 20), you can experiment with the wind turbine outdoors. Set it up where you can secure it by pushing the three stakes into the ground. Be sure it has enough space to spin freely!

**Indoors:** If the wind isn't blowing or is blowing too strongly, you can set up the wind turbine about 1–2 feet from a fan.



## EXPERIMENT 5

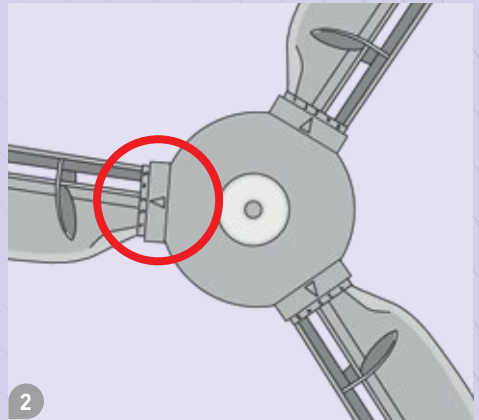
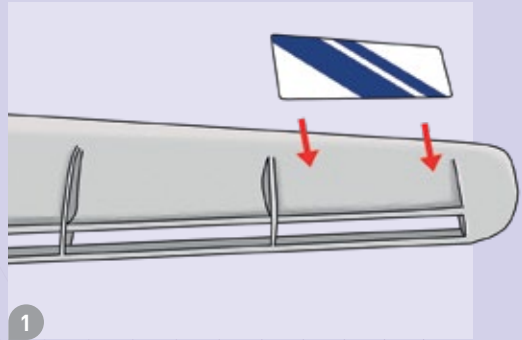
# Optimizing the rotor blade setting

## You will need

- Wind turbine
- Car
- Fan
- Adhesive tape and paper
- Stop watch
- Pen and paper

## Here's how

1. Set the switches and blades as in the previous experiment, and position the fan in a fixed place in front of your wind turbine. Mark one of the rotor blades by sticking a small piece of paper to it with adhesive tape. This will make it easier to count the revolutions per minute.
2. Choose a setting for the angle of the rotor blades. All rotor blades must be set to the same angle.
3. Carry out a series of tests, noting the rotations per minute for each blade setting.  
**Which setting leads to the most rotations per minute?**
4. Now test what happens when the blades are each set to different angles at the same time.



BLADE SETTING	ROTATIONS PER MINUTE
1	
2	
3	
4	
5	

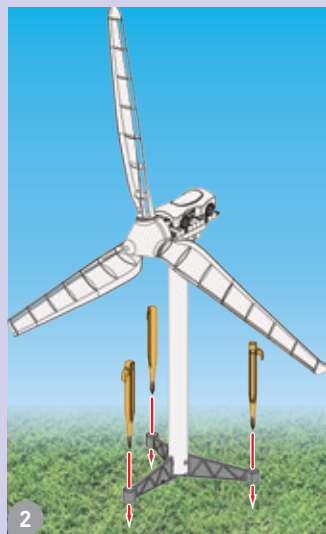
## Optimizing the location

### You will need

- Wind turbine
- 3 stakes

### Here's how

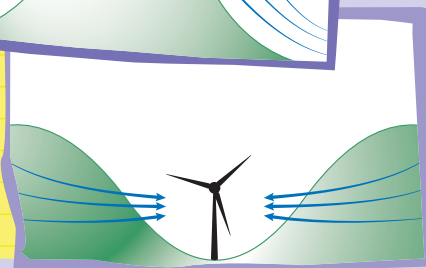
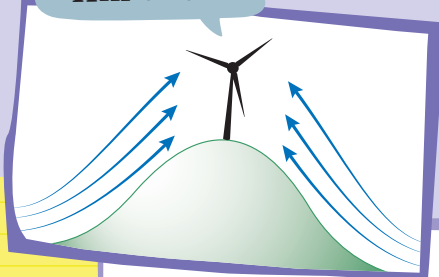
1. In wind conditions between 2 and 4 on the Beaufort scale (see p. 20), you can experiment with the wind turbine outdoors. Set the rotor blades to position 3, the switch on the side to the turbine symbol, and the switch on the back to IN.
2. Anchor the wind turbine securely with the stakes, so that it cannot easily be pushed over.
3. Think about possible locations for your wind turbine. How about on the next hill or in a narrow alley between houses? Is it a good idea to take it to the nearest forest?



### WHAT'S HAPPENING?

Generally speaking, the higher the turbine is placed, the more wind will hit it, since there are no obstacles blocking the wind. However, with the right wind direction, a narrow alley can also increase wind speed by channeling it into a smaller space. This is known as the **wind tunnel effect**.

### Hill effect



### Tunnel effect



**EXPERIMENT 7**

## Identifying Wind Conditions

### You will need

- Wind turbine, set up outdoors
- Beaufort scale (page 20)
- Computer or smart device
- Compass

### Here's how

1. In numerous places globally, weather stations are used to determine wind direction and wind strength. If necessary, ask an adult to help you find this data on the internet.
2. Your wind turbine works best when it exactly faces the direction from which the wind is coming. With the help of a compass and information from the internet, you can set it up optimally. Alternatively, you can also find out the wind direction by observing how trees and grass move.
3. Make sure that all switches are set correctly (rotor blades on position 3, side switch on turbine symbol, rear switch on IN) and watch your wind turbine charge your electric car with clean energy.







## CHECK IT OUT

# Energy from wind

The wind that surrounds us can develop enormous power depending on its speed. You used the moving air to rotate your wind turbine's rotor blades. But how did that actually generate electricity? Under the cover of the motor/generator is a magnet that sits inside of a coil of conductive wire. When the magnet is rotated, by the hand crank or the wind, electricity is generated in the wire. This is also how electricity is generated at power plants. Instead of wind power rotating the electromagnet, oil or gas are burned to create the steam required to turn the turbines.



## Transportation

Unfortunately, it is not windy enough everywhere to generate electricity on a large scale. That's why there are power lines that bring the generated electricity to where it's needed. But the farther electricity needs to travel through lines, the more power is lost in the process.



**SETUP AND TROUBLESHOOTING**

## Wind power:

### 1. Rotor blades:

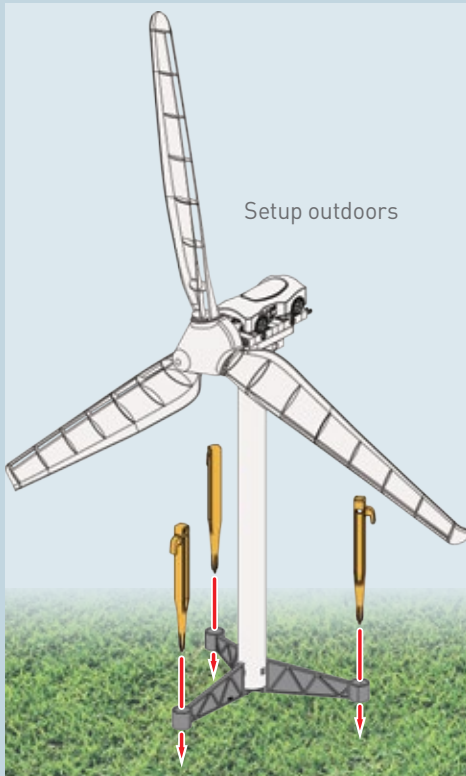
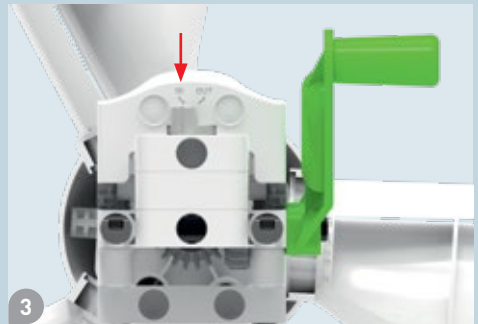
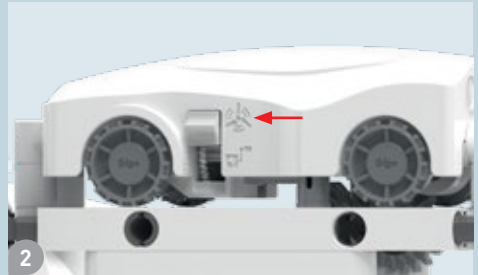
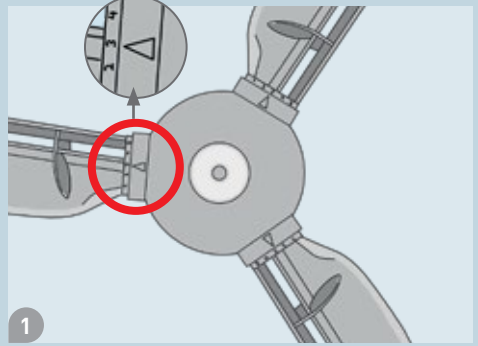
All rotor blades must be set to the same position. Usually, position 3 works best.

### 2. Side switch:

To charge with wind power, the switch on the side of the car must be turned to the wind turbine position.

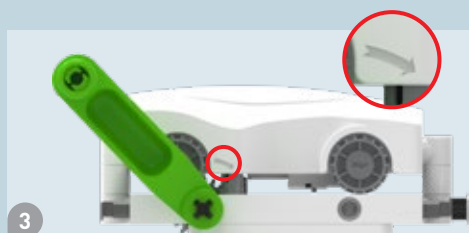
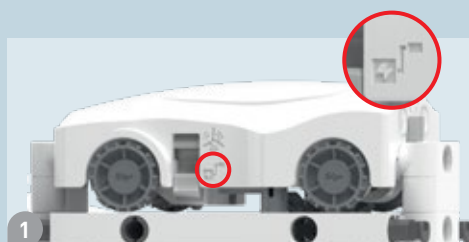
### 3. Back switch:

The switch on the back of the car must be switched to IN for electricity to be generated and stored.



## Hand crank:

1. Set the switch on the side of the car to the symbol with the hand crank.
2. Set the switch at the back of the car to IN.
3. Turn the crank in the direction of the arrow on the side of the car.



## Troubleshooting

**IMPORTANT:** Turning the crank in the wrong direction may cause the internal plastic gears to slip. This causes the switch on the side to slip to a middle

position. To set it back to the correct position, first set it to the wind turbine position, and then push it back down to the hand crank position.



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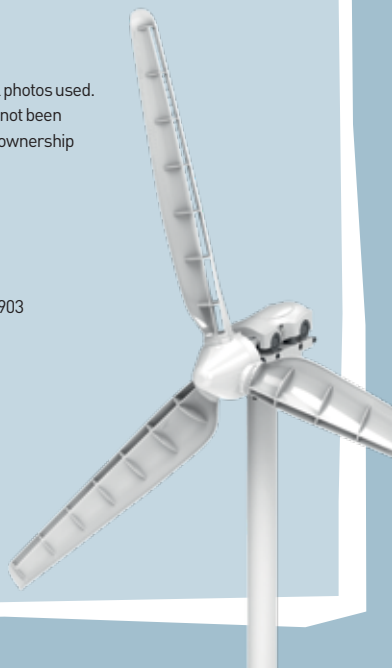
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