



ثانوية التكنولوجيا التطبيقية  
Applied Technology High School

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# Technology Exploration\_II

## Module 1 Electrical Machines



PREPARED BY

**Academic Services**

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# Module 1: Electrical Machines

## Module Objectives

After the completion of this module, students should be able to:

- Define energy.
- Differentiate between the different forms of energy.
- Draw energy transfer diagrams.
- Give examples of electrical machines.
- Define the purpose of motors and generators.
- State the function of a capacitor.
- State the purpose of a Power Distribution Network.
- Conduct practical tasks to demonstrate the application of motors, generators, and capacitors.

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## 1.1 Introduction to Energy

What is energy?

Energy does things for us. It makes televisions and laptops work. It moves cars along the road and boats on the water. It helps our bodies grow and makes us do things. Energy is the ability to do work.

What are the different forms of energy?

Energy can have several forms, but they all fall into two main types- potential or kinetic.

**Potential energy** is the energy stored in an object/body due to its position. Examples of potential energy are, water in a lake in the mountains, or an object held at a certain height as shown in figure 1.1. Gravity gives potential energy to an object.

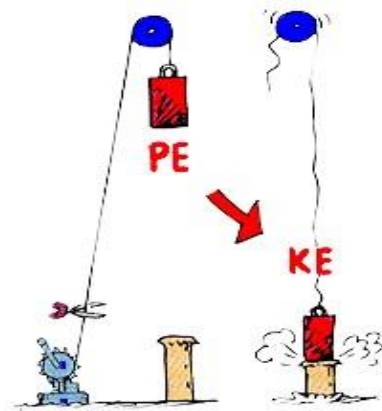


Figure 1.1: Potential energy example

**Kinetic energy** is the energy which a body has due to its motion. A boy running, flowing water and wind are good examples of kinetic energy. Electricity is also kinetic energy because it involves the movement of electrons.



Figure 1.2: Kinetic energy example

## Transfer of Energy

Energy can be changed or transferred from one form to another. An example is the roller coaster illustrated in figure 1.3. When it is on its way up, it is using kinetic energy since the energy is in motion. When it reaches the top it has potential (or stored) energy. When it goes down the hill it is using kinetic energy again.



Figure 1.3: Roller coaster

The example of a cycle rider (shown in figure 1.4) riding to the top of the hill, and then downwards demonstrates how the energy is transferred from one form to another during his ride.

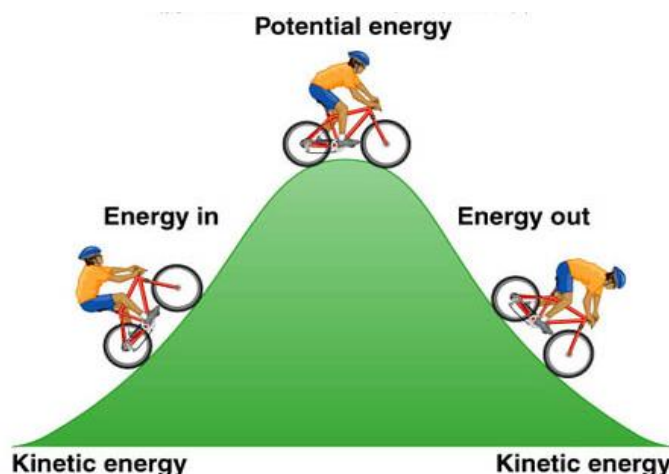


Figure 1.4: Cycle rider

## Other Forms of Energy

Examples of other forms of energy are light energy, heat (or thermal) energy, chemical energy, electrical energy and so on. This module will focus on electrical energy, and the electrical machines.

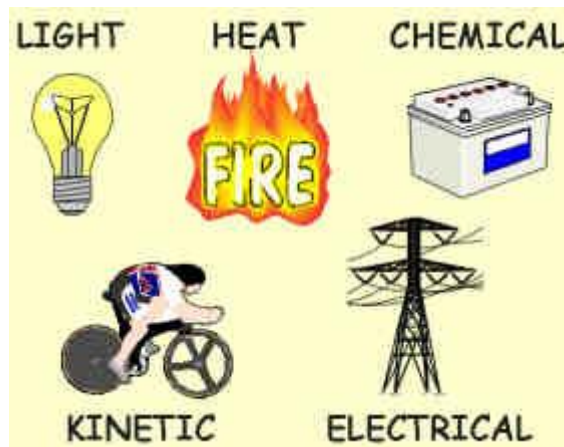


Figure 1.5: Energy forms

Some energy changes (transformations) are useful, while others are not.

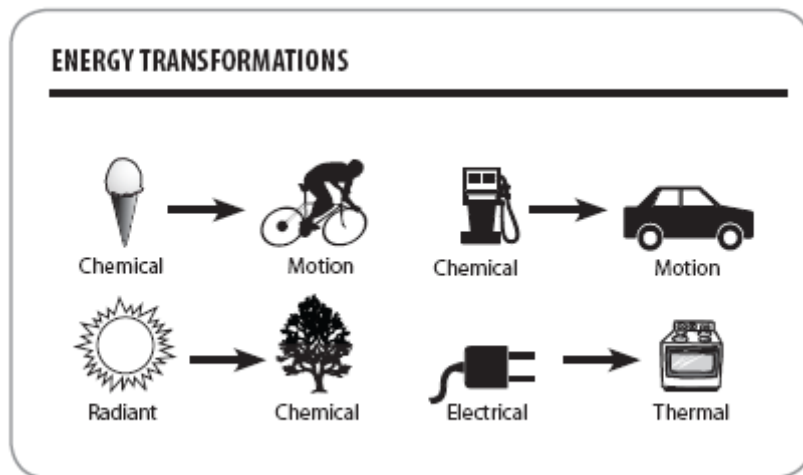


Figure 1.6: Energy transformation

For example, a windmill collects kinetic energy from the wind and converts it into useful mechanical and electrical energy. The Chinese used windmills to water their farms as illustrated in figure 1.7. This kind of energy is called Renewable Energy. This will be covered in details in

## Module 2.

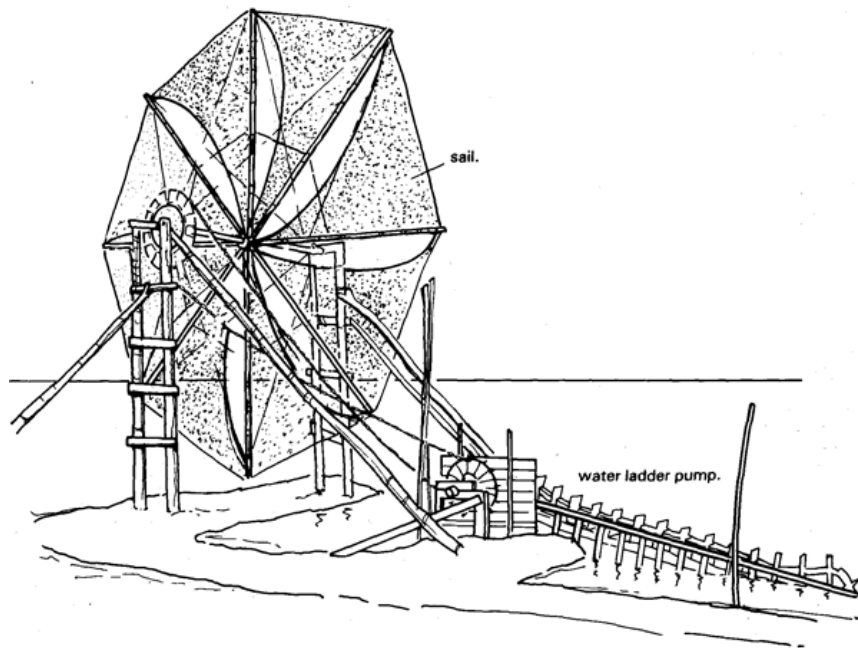


Figure 1.7: Windmill

**Class Activity 1:**

Energy transfer tables and diagrams are an excellent way of displaying the energy transfers taking place in a process. Complete the energy transfer table given below:

<b>Energy Converter</b>	<b>Energy in</b>	<b>Energy out</b>	<b>Other Energy out</b>
Windmill	Wind	Mechanical	Electrical
Food	Chemical Energy	Kinetic Energy	Many others
Solar cells	Solar Energy	Electrical Energy	Many others
Generators	Mechanical Energy	Chemical Energy	Electrical Energy
heaters	Electrical Energy	Heat/ Thermal energy	Light Energy
Water turbines	Kinetic Energy	Mechanical Energy	Electrical Energy

## 1.2 Electrical Energy

Electrical energy is what is stored in a battery, and can be used to power a cell phone or start a car. Electrical energy is delivered by tiny charged particles called electrons, typically moving through a wire.

### Generating Electrical Energy

Electrical machine is a device that converts either mechanical energy to electrical energy or vice versa. **Motors** and **generators** are examples of electrical machines.



Figure 1.8: DC Motor

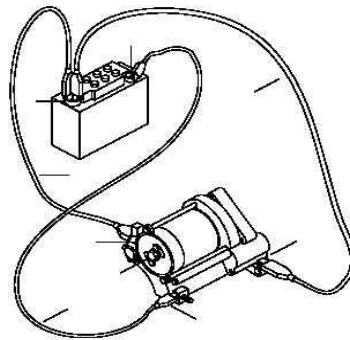


Figure 1.9: DC Motor connected to a battery

If a motor is connected to a battery as shown in figure 7.9, the motor will turn. Here it converts electrical energy to kinetic (Mechanical) energy.

A motor can also be used to generate electricity, and when a motor functions in this way, it is called a generator or a dynamo. Electricity is generated when the axle of the motor is turned.

## Storing Electrical Energy

A capacitor is a device that could be used to store electrical energy. Unlike the battery, it does not use chemicals to store the electricity. It is made from two metal plates with a thin layer of insulator in between them. When the capacitor is charged (filled), the positive (+) charge goes on one plate, and an equal negative (-) charge goes on the other plate. When the capacitor is discharged (empty), both plates will have no charge.

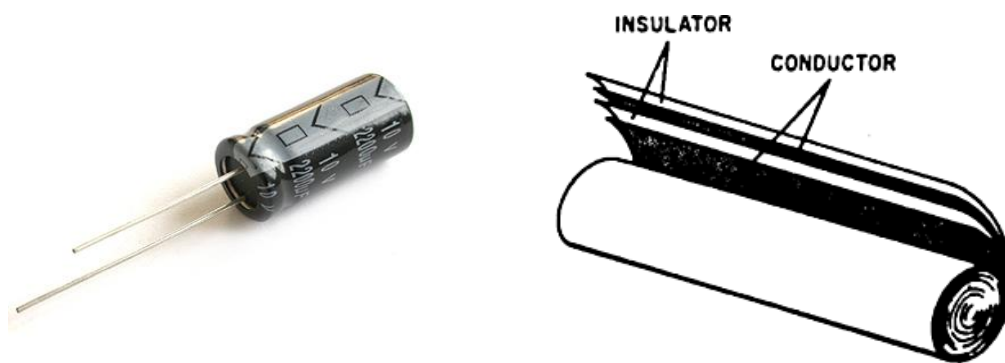


Figure 1.10: Capacitor



### 1.3 Practical Tasks

#### 1.3.1 Task 1:

1. Connect the Lego motor to a battery and watch the motor run. In this case, the motor converts electrical energy to mechanical energy.
2. Attach a large pulley wheel to the motor axle. A grey connector peg makes a good handle. Add two green tiles to show that the motor is being used as a generator of electricity.

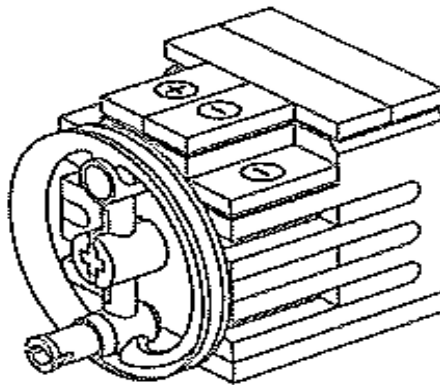


Figure 1.11: Generator

3. Turn the handle and feel how it turns
  - a. Was it easy or hard to turn the handle?  
easy
  - b. When you turn the handle, what sort of energy do you put in?  
mechanical energy

4. Connect a lamp at one end of a connecting wire and attach the other end to the motor/generator. Turn the handle to light the lamp. Feel how it turns.

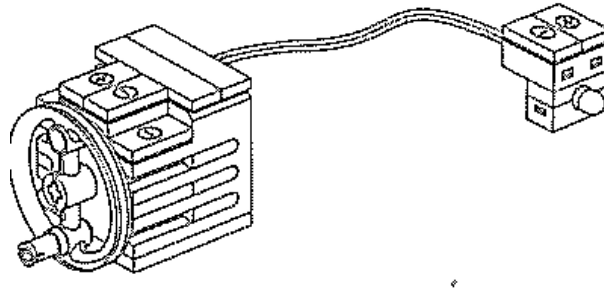


Figure 1.12: Lamp connected to the generator

- a. Was it easier or harder to turn the handle than before?

harder

- b. Is the motor used as a generator in this activity?

yes

5. Write down the energy transfer taking place in a generator:

From mechanical to electrical

6. Explain why it is harder to turn the handle when the lamp is connected?

the load of the generator has increased

7. Write down the useful energy transfer in a lamp.

From electrical to light

8. Complete the energy transfer diagram for the lamp.

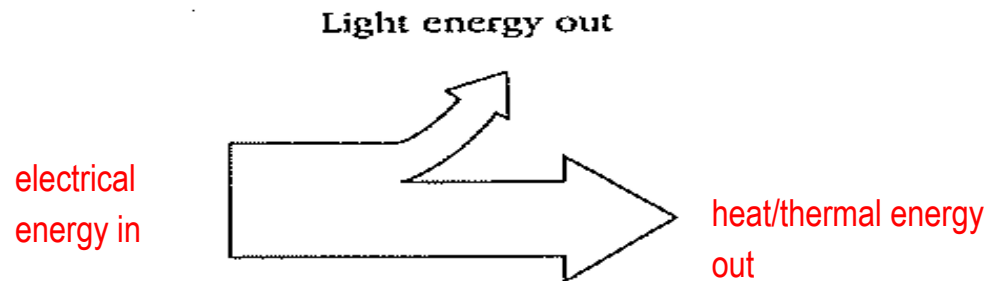


Figure 1.13: Lamp connected to the generator

9. Which form of energy do we get from the lamp that we do not use?

heat/thermal

### 1.3.2 Task 2: Connect a generator to drive a motor

1. Connect a motor to a generator with a wire. Put a large pulley wheel on each. Add a connector peg to act as a handle on the generator. Add two green tiles to indicate that it is a generator.

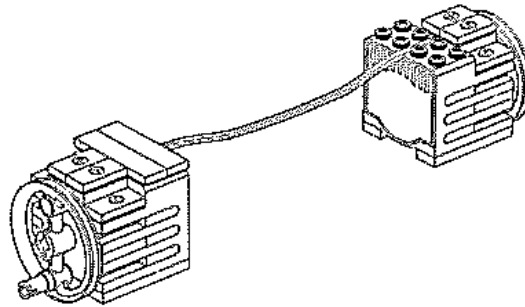


Figure 7.14: Motor connected to the generator

2. Turn the generator handle. Watch what happens to the pulley wheel on the motor. What is your observation regarding the other motor?  
The pulley wheel of the motor will rotate. This is because the electrical energy of the motor is transferred into mechanical energy
3. Use a force-meter to measure the force needed to turn the generator handle. What force was needed (in Newtons)?

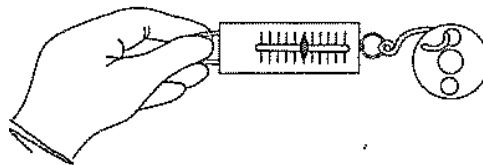
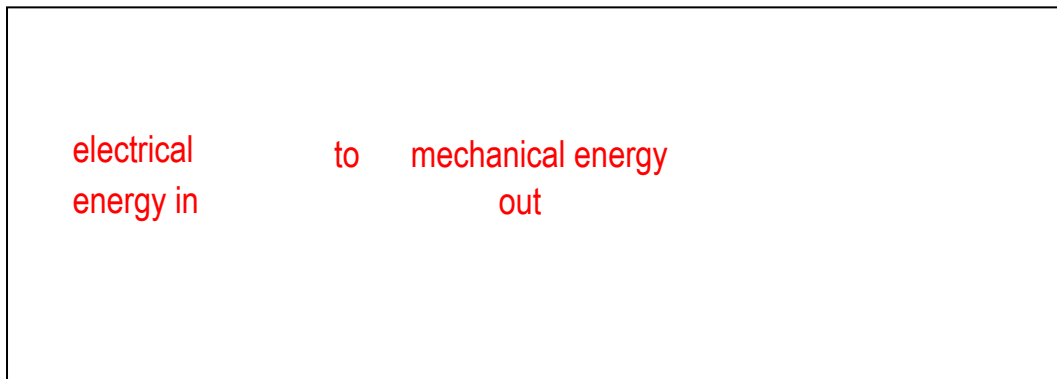


Figure 7.15: Measuring force with a force-meter

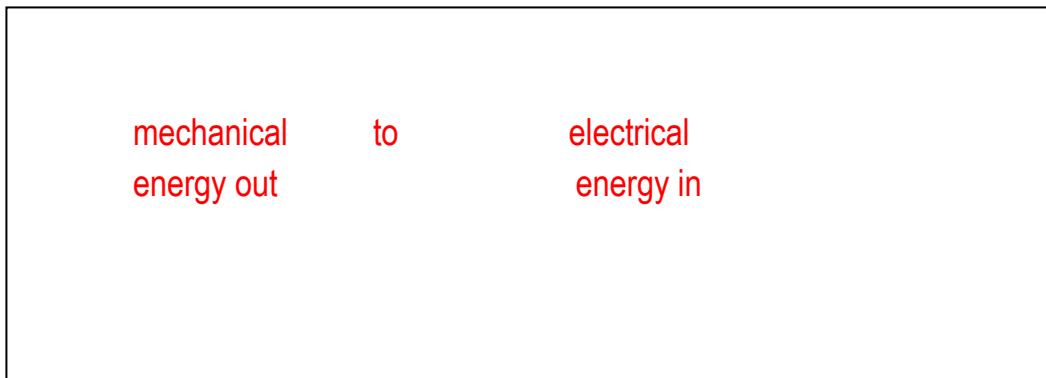
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4. Draw an energy transfer diagram for the motor.



5. Draw an energy transfer diagram for the generator.



### 1.3.3 Task 3: Storing Electrical Energy

In this task, you will see how a capacitor could be used to store electrical energy.

1. As a first step, check that the capacitor is discharged or empty. This can be done by connecting the capacitor to the motor as shown in figure 1.16. The motor will not turn if the capacitor has discharged.
2. Put a large pulley wheel on the axle of the motor and add a grey connector peg to make a handle. Add two green tiles to indicate that it is a generator.
3. Now, connect the capacitor to the generator. Take care to connect it as shown on page 18 of the building booklet.

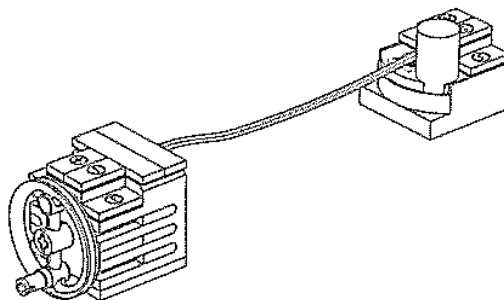


Figure 1.16: Capacitor connected to the motor

4. Turn the handle clockwise a few times then let go. What happens to the pulley?

it will rotate counter clockwise

5. When it is discharged (motor stops turning) try turning it 20 turns. What was different?

it will rotate counter clockwise for a longer period of time

6. Next try turning the handle until the red light shows that the capacitor is fully charged. What was different?

it will rotate for a much longer time.

### 1.3.4 Task 4: Power Distribution Network

This activity will let you build an electricity grid system.

1. Attach a handle and green tiles to the generator, then connect a motor to the generator. Turn the generator. Note what happens to the motor and how hard it is to turn the generator handle.

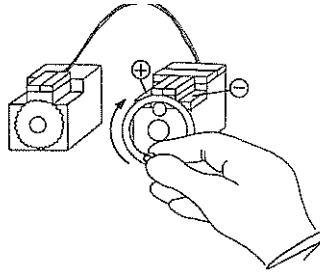


Figure 1.17: Motor connected to the generator

2. Now connect a lamp and another motor.

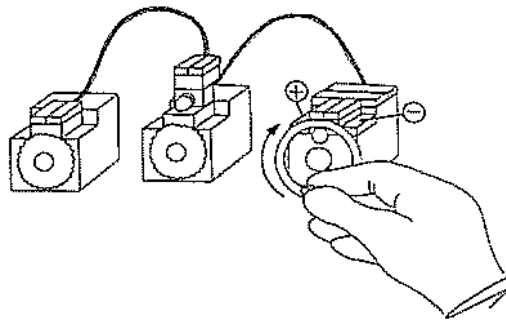


Figure 1.18: Lamp connected to the motor and generator

Keep turning at the same speed and feel how hard it will turn. When you add more load what happens to:

- a. The torque (turning force) needed by the generator?

the torque is increased

- b. The motors and lamps?

the motor will slow down and the lamp will be dim

- c. What happens to the motors when you stop generating

electricity?

it will stop rotating

3. Add a second generator to your system.

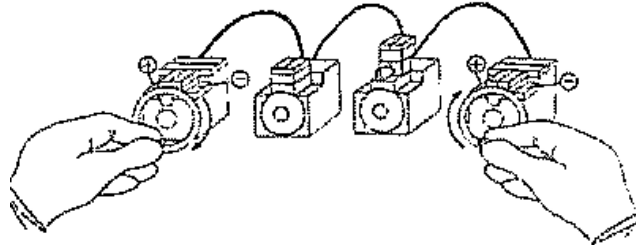


Figure 1.17: A second generator connected to the system

What happens to:

- a. The torque needed by the first generator when the second generator was added?

the torque will reduce

- b. The motors and lamps?

the motors will rotate faster and the lamps will be bright

4. Having a real power station on standby, ready to take over when demand is high, is very expensive. A storage capacitor could be added to smooth out demand.

Connect a generator, capacitor and motor. Check the connections.



Turn the handle to generate electricity to charge the capacitor and turn the motor. What did you notice about the torque (turning force) as the capacitor charged up?

the torque will reduce gradually as the capacitor charges up

5. Add a lamp, or second motor.

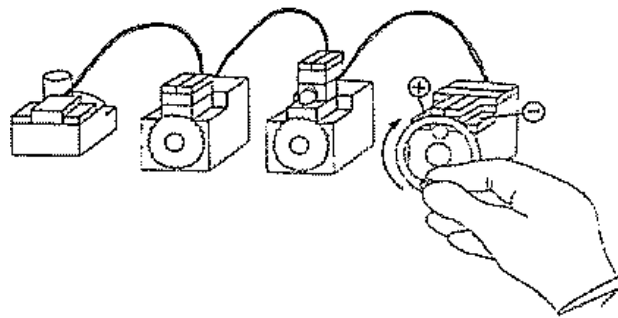


Figure 1.18: Generator, lamp, motor and capacitor connected

What happens when you start turning the generator?

the lamp will be brighter and the motor rotation speed will increase

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## 1.4 Worksheet

1. What are the two main types of energy?

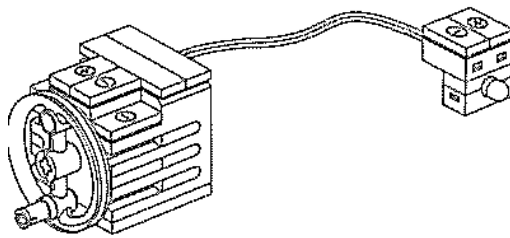
kinetic energy

potential energy

2. Classify the following examples as potential and kinetic energy:

- Flowing water    kinetic energy
- A ball held at a certain height    potential energy
- A stretched rubber band    potential energy and elastic energy
- A boy running    kinetic energy

3. A lamp is connected to the generator as shown in the figure below.  
The lamp turns on when the handle of the generator is turned.



Draw the energy transfer diagram for the lamp.

mechanical energy to electrical energy to light and heat energy

4. Complete the energy transfer table given below:

<b>Energy Converter</b>	<b>Energy in</b>	<b>Energy out</b>	<b>Other Energy out</b>
Windmill	wind/kinetic_____	mechanical_____	electrical_____
Car engine	chemical_____	electrical_____	mechanical_____
Electric lamp	electrical_____	light_____	thermal/heat_____