Energy consumption

NaRiKa Corporation

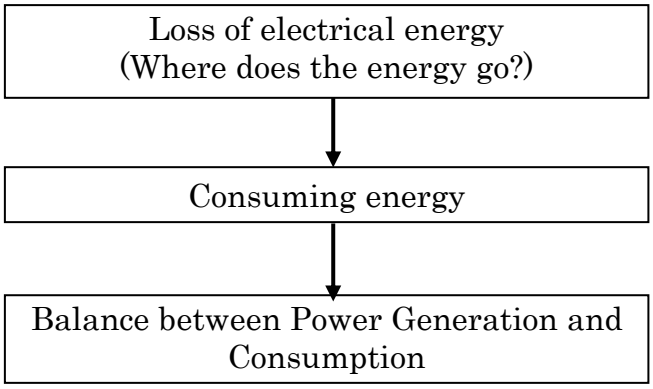
1. Learning Outcome

As a supplementary curriculum, in this unit, teachers help students understand how electricity is transferred from power stations to the towns/homes while some of the power is consumed (lost) on the way and not all of the generated power can reach to us due to the energy conversion from electricity to heat.

Based on this understanding, students learn basic concept like “Power consumption” and “Amount of Power Consumption” through the experiment to realize that a equipment of larger energy consumption requires more electric power. Also, students will know various type of fuel (source of energy) is needed to generate electric power.

Finally, students will go through the experiment to understand the balance between power generation amount and power consumption. Students to know blackout may happens in case power consumption surpasses the amount of power generation.

2. Overall Learning Scheme



3. Preparation for Experiment

In this unit, use the instrument as follows.

- P70-0395-10 Miniature Bulb and Socket (holder) with Leads & Clips: 10
- B10-2632-W0 GENECON DUE: 1
- B10-2634-W0 GENECON V3: 2
- B10-2700-W0 GENECON Light Box: 1
- Wooden Basement for Experiment 1

1. Miniature Bulb and Socket with Leads & Clips (P70-0395-10)

A miniature bulb is embedded in a socket (with a lead and electrical clips). Even early elementary grade students can connect it to dry-cell battery holder and electrical circuit.

Also, suitable for the experiment to light a miniature bulb with electrical energy stored by using B10-2632 GENECON DUE.

2. GENECON DUE & V3 (B10-2632-W0, B10-2634-W0)

GENECON is a user-friendly hand-held DC (Direct Current) generator extremely useful for the power generation to be used for experiments of energy conversion and electrolysis of water. GENECON DUE produces (up to) approx. 12V DC only by turning the handle. GENECON V3 produces (up to) approx. 3V DC only by turning the handle. GENECON is a power generator specialized for the educational use to self-produce electricity.

GENECON is quite simply designed with the built-in motor inside that works to generate power. Students may realize the structural interaction of embedded motor, gears, shafts and handle through the transparent body. Teachers may easily instruct the students about the identical/interchangeable correlation between “motor” and “generator”.

GENECON V3 (DC3V Type)

GENECON DUE (DC12V Type)

	GENECON V3	GENECON DUE
Available generating voltage	approx. 3V	approx. 12V
Most suitable bulb	2.5V Type	6.3V Type

[Note] Specifications differ between GENECON V3 and GENECON DUE. In case lighting a miniature bulb 6.3V type, use GENECON DUE instead of GENECON V3. If you light 2.5V type with GENECON DUE, the bulb would be shortly broken.

3. GENECON Light Box (B10-2700-W0)

This is an experimental apparatus to light each of three types; incandescent lamp and LED (light-emitting diode) lamp, by using GENECON DUE, and then, to compare the heaviness of GENECON handle (e.g. to feel how much differently loaded) in either case of lighting the

incandescent lamp and LED lamp, which is being equipped with the latest electronics technology, students would further be interested in issues of the energy consumption.

[Specification]

Input: DC 12V
Size: 245 x 175 x 100 mm
Incandescent lamp: 12V 20W
LED lamp: 10~15V 2.5W

[Note]

1) This apps is designed to be used exclusively in combination with Genecon DUE. Hence, Genecon V3 is not adequate for this apps.

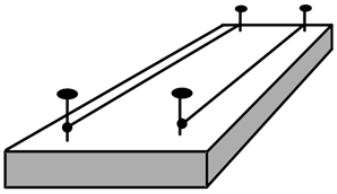
2) Don't plug in the apps directly to wall socket (AC100V～AC240V) as it might catch fire.

4. Wooden Basement for Experiment

This is a "Wooden Basement for Experiment" for the connections of multiple miniature bulbs. Note that this is not-for-sales product to be prepared by schools.

- Size: approx. 75 x 180 x 10 mm
- Nails or screws: x4, Total length: around 20 mm,
- Wires: x2

Fix four nails or screws on a rectangle-shaped wooden piece, and then connect wires as shown in the right-hand figure.



4. What is electric energy consumption and amount of consumed electric energy

We are using all kinds of home electric appliances. We have learned the other day by using incandescent bulb, fluorescent bulb and LED bulb that it depends on which type of bulb we are using, and accordingly to that the (load) heaviness of turning the handle of Genecon differs. The cause of the difference in load depends on the required amount of electric energy of the other side and we have learned that it is called electric consumption of the other side.

We call consumption of electricity of home electric appliances and other appliances "electricity consumption".

Electricity consumption [W] = Voltage [V] x Current [A]

And we call one hour of electric consumption “amount of electric consumption per hour”.

Amount of electricity consumption [Wh] = Electricity consumption [W] x Time [h]

On electric appliances, there is electricity consumption (W) and amount of electricity consumption (Wh) specified on label. Let’s check your home electric appliances and write it in table below.

Electric appliance	Voltage〔V〕	Electricity consumption〔W〕	Amount of electricity consumption〔Wh〕
Refrigerator	〔V〕	〔W〕	〔Wh〕
Television	〔V〕	〔W〕	〔Wh〕
	〔V〕	〔W〕	〔Wh〕
	〔V〕	〔W〕	〔Wh〕

* Be sure to verify the Electricity consumption and/or Amount of electricity consumption of your home appliances in advance. No problem even if only one of them is verified.

1. What is “consumption”? (Demonstration)

We did experiment with the “Genecon Light Box” previously. Please recall how the heaviness of rotating the handle of Genecon DUE was different depending on which light we were lighting up, if it was incandescent bulb, fluorescent light or LED bulb. Voltage, electric consumption and amount of electric consumption of incandescent bulb, fluorescent light or LED bulb are in table below.

Incandescent bulb: 12V
Electric consumption
= 20W amount of electric consumption = 20Wh

LED bulb: 10V
Electric consumption
= 2.5W amount of electric consumption = 2.5Wh

By comparing incandescent bulb and LED bulb we can see that incandescent bulb has amount of electric consumption 20Wh while LED bulb has 2.5Wh. Therefore, we can see that incandescent bulb consumes 8 times more electric energy than LED bulb (in other words: LED bulb consumes 1/8 of electricity consumed by incandescent light). During the experiment we could confirm that the LED bulb was much brighter than incandescent bulb. That means, LED

bulb by consuming less electricity is lit brightly.

Proportion of Power consumption that is converted to the Light energy is;

- 3~5% for incandescent lamp,
- 2~25% for LED lamp,
- Around 28% for fluorescent lamp,

rest of which is converted to thermal energy.

Consumption of electricity means electric energy that is necessary for the electric appliance to work is equal to the electricity consumption (amount of electricity consumption) used. In other words: electric energy which is necessary for operation of electric appliance is not equal to the electricity consumption (amount of electricity consumption) obtained then the electric appliance will not work.

In order for us to use electrical goods,
↓
Necessary Electric energy (amount of electricity consumption)
↓
Generated Electric energy (amount of generated Electric energy)
↓
Kinetic energy necessary for generation of Electric energy
↓
Thermal energy necessary for kinetic energy
↓
Fuels such as coal or oil necessary for Thermal energy

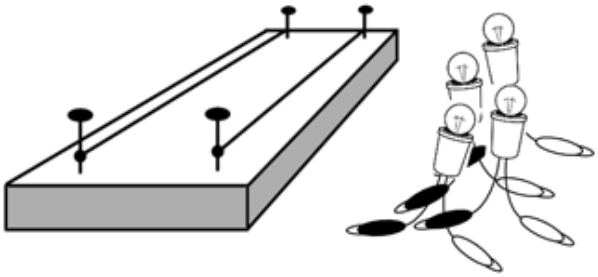
In order to use electrical appliances at home, to be able to obtain necessary energy (amount of electricity consumption) for electrical appliances, that amount has to be generated. In addition, to obtain necessary kinetic energy for electric energy generation, thermal energy to heat boiler is necessary. To obtain thermal energy fuels such as coal or oil is necessary. And in each step and even between the steps there always occur energy loss. Therefore, we have to carefully use our resources and do not waste them.

2. [Experiment 1] Miniature bulb(s) in parallel circuit

1. Experiment procedure

1) Craft the (wooden/hand-made) Parallel Circuit Base using 4 nails and 2 wires as shown in below figures.

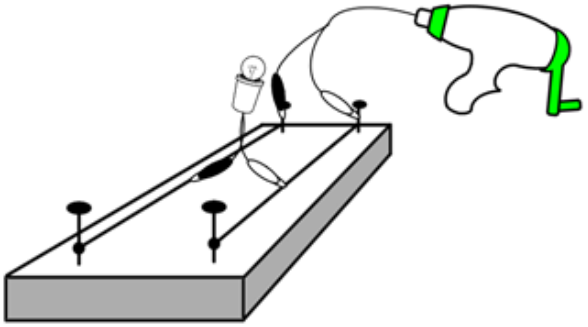
2) Prepare four "Miniature Bulb Holders with leads" socketed with a miniature bulb for each holder. Note: Use miniature bulbs rated at 2.5V or 3.8V.



3) Connect one "Miniature Bulb Holder with lead and bulb" to the wires as shown in the figure.

4) Connect a Genecon V3 with the wires (circuit) as shown in the figure.

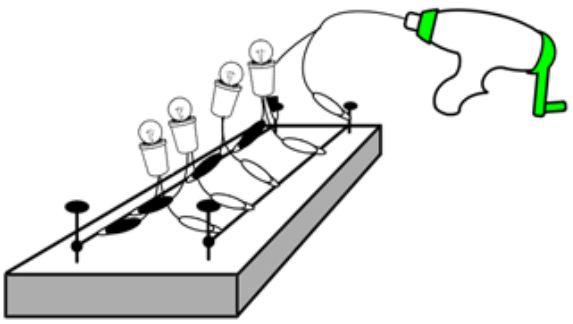
5) Light the bulb by turning the handle of the Genecon V3.



6) Increase the numbers of the bulbs connected with the circuit one by one, and every time doing so, light the bulbs by turning the handle of Genecon V3.

7) Once the numbers of the bulbs connected are increased up to four, repeat the experiment re-starting the number of only one bulb connected.

8) Record (the change of) the heaviness (load) the person turning the handle would feel.



It is crucial for students to be aware through the heaviness (load) of the handle of Genecon in combination with miniature bulbs, as a simulated modeling, to know how a generator is affected when the energy consumption is increased.

Hence, teachers should secure enough time so that each student can go through the heaviness (load) change of the handle in person.

Even if some students may connect more than four bulbs, just overlook and let them do as they like.

2. Experiment results

Fill the below spreadsheet with the results. Describe the heaviness (load) the person turning the handle would feel like “light”, “normal” or “heavy”.

Numbers of bulbs connected	Heaviness (load) the person turning the handle would feel	Remarks
One		
Two		
Three		
Four		

Q1. Describe how the heaviness (load) has (has not) changed by the increased numbers of the bulbs.

Express above “Experiment results” spreadsheet in language.
The handle becomes heavier as the number of bulbs connected to the circuit is increased.

Q2. Why the heaviness (load) of the handle changed as mentioned as the answer for Q1.

The more bulbs are connected to the circuit, the more electrical quantity is needed to light them. The handle becomes heavier to generate equivalent power.

In other word, if the number of bulbs connected increases, more electrical quantity needs to be provided equivalent to the increased power consumption, and then, the handle becomes heavier.

3. [Experiment 2] Correlation between the numbers of bulbs connected with Parallel Circuit and numbers of turns of Genecon handle

Recall previous experiment of "motor" and "generator" both of which connected with a circuit. This experiment is based on the electrical energy produced by a "generator" to be consumed by bulb(s) and rest of (surplus of) the electrical energy would be used for turning a motor ". Thus, it aims to measure how much electrical energy was consumed by the bulb(s) in accordance with the difference between the numbers of the handles' turns of two GENECONs.

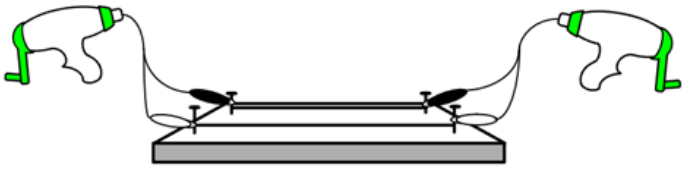
1. Experiment procedure

1) Connect two GENECON V3 with the (wooden/hand-made) Parallel Circuit Base.

2) Assume one of them (one shown of the right end) as a "generator" and the other one as a "motor".

3) Turn the handle of the "generator" ten times.

4) Record how many turns the "motor" handle makes.

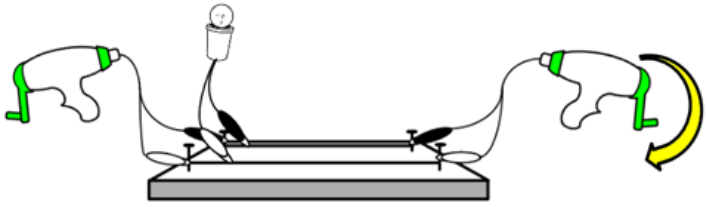


(Motor) (Generator)

5) Connect bulbs with the circuit as shown below.

6) Turn the handle of the "generator" GENECON V3 ten times.

7) Record how many turns the "motor" GENECON V3's handle makes.

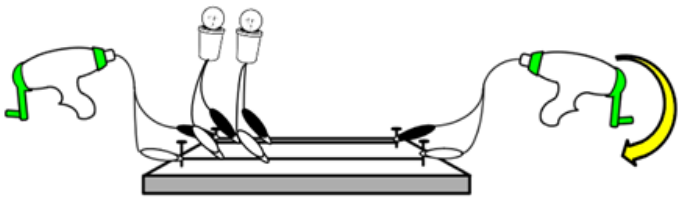


(Motor) (Generator)

8) Connect another bulb with the circuit as shown below.

9) Turn the handle of the "generator" GENECON V3 ten times.

10) Record how many turns the “motor” GENECON V3’s handle makes.

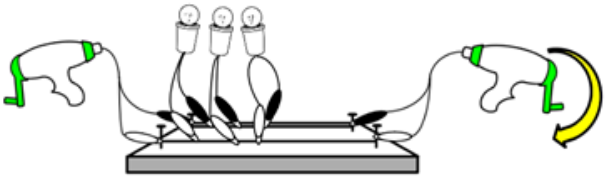


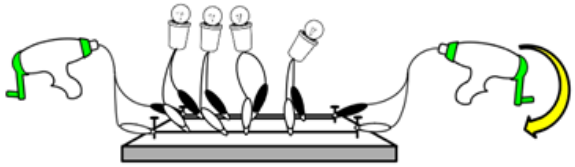
(Motor) (Generator)

Note: Keep the brightness of the 1st bulb connected when more bulbs are connected by appropriately turning the handle of the “generator” GENECON V3.

11) In the same way, increase the numbers of the bulbs connected with the circuit, and turn the handle of GENECON V3 ten times every time you increase the number of the bulbs, and then, record how many turns the “motor” GENECON V3’s handle makes.

Note: More bulbs are being connected, tougher it will be to maintain the same level of brightness. Hence, try to turn the handle of GENECON V3as much/briskly as possible.





12) Repeat this experiment up to about 3rd round.

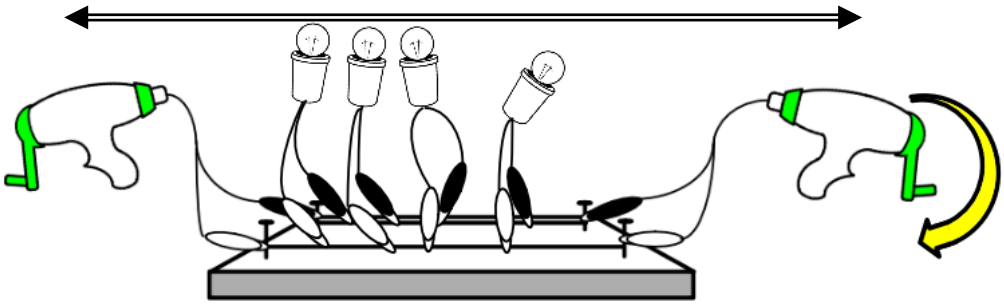
2. Experiment result

	Rotation number of the “generator” (A)	Rotation number of the “motor” (B)	Number of bulbs	Rotation number consumed in the circuit (A) – (B)
1st round	10 Turns	〔 〕 turns	1	〔 〕 turns
		〔 〕 turns	2	〔 〕 turns
		〔 〕 turns	3	〔 〕 turns
		〔 〕 turns	4	〔 〕 turns
2nd round	10 Turns	〔 〕 turns	1	〔 〕 turns
		〔 〕 turns	2	〔 〕 turns
		〔 〕 turns	3	〔 〕 turns
		〔 〕 turns	4	〔 〕 turns
3rd round	10 Turns	〔 〕 turns	1	〔 〕 turns
		〔 〕 turns	2	〔 〕 turns
		〔 〕 turns	3	〔 〕 turns
		〔 〕 turns	4	〔 〕 turns

Number of bulbs	1	2	3	4
Rotation number consumed in the circuit (in average)	[ ] Turns	[ ] Turns	[ ] Turns	[ ] Turns

3. Reviewing the results

Q1. We know difference between the number of the handles' turns of two GENECONs ("Motor" and "Generator") means the "Rotation number consumed in the circuit".
Then, indicate the entire "circuit" in the below figure using the mark of ← →.



(Motor) (Generator)

Q2. Describe why the heaviness (workload) of the handle of the "generator" get increased as the number of bulbs connected increases from one to four.

[For your review] The more bulbs are connected to the circuit; the electrical quantity is needed to light them. The handle becomes heavier to generate equivalent power.
In other word, if the number of bulbs connected increases, more electrical quantity needs to be provided equivalent to the increased power consumption, and then, the handle becomes heavier.

Q3. Describe how the bulbs would be/not be lit differently if more bulbs are connected.

If more bulbs are connected, the brightness would become darker as the (whole) quantity of power consumption in the circuit is increased.

[Reference Information -1-]

We went through connecting miniature bulbs to the parallel circuit for the previous experiment.

Most of the electric appliances located in houses and factories are connected in parallel in order to prevent any negative affection from appliance(s) that is broken down to others, and, to easily identify which one(s) went wrong.

If they were connected in series, all of the appliances in an area would not work altogether and it would be so difficult to identify which one(s) has problem.

[Reference Information -2-]

Fail-safe device, so-called Circuit Breaker, is always equipped in houses/offices. Circuit Breaker to be automatically operated to shut-off the overloaded current when it surpasses a certain amount of energy consumption as we went through the “blackout” experiment by connecting many miniature bulbs in a circuit.

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