Wisconsin Energy Institute
UNIVERSITY OF WISCONSIN-MADISON

MICROGRIDS:
SUSTAINABLE ENERGY EXPLORATION STATION

Overview

This Exploration Station is designed to introduce learners to the basics of microgrids and new approaches to generating and distributing electrical power in communities. "Exploration Stations" are educational activities that invite learners to interact with materials in a hands-on manner at their own pace. Learners will discover the advantages of microgrids through the manipulation of educational circuit boards that incorporate renewable energy components in tandem with the existing utility grid. Learners can spend as much time with the activity as they choose. One or more facilitators lead the activity, taking cues from the learners and encouraging scientific inquiry and experimentation.

What is a Microgrid?

A microgrid is a small, self-contained electric-power grid with the capacity to connect and disconnect seamlesssly from the traditional grid. It includes all the components of the traditional energy system (generation, distribution, and consumption) shrunk to accommodate a smaller consumer base, such as individual buildings, hospitals, military bases, universities and neighborhoods. Powering communities with microgrids offers several advantages such as increased reliability and efficiency, and reduced fossil fuel use through the incorporation of clean energy sources. To learn more about microgrids and this activity watch our short introductory video available here (https://youtu.be/78r7FwasjlM).

The exploration station uses the "Snap Circuits Green Kit" made by the company Elenco. "Snap Circuits" are designed for children to experiment with building different electronic circuits that perform various functions, such as lighting up LEDs or turning on a radio. The WEI Microgrid Exploration Station demonstrates two separate scenarios. One "Main Grid" station is set up to show how one's "neighborhood" is conventionally attached to a main utility grid that is fed by a power plant. Another "microgrid" station shows how different renewable energy sources, like wind and solar power, are incorporated into small-scale local generation and distribution that could also serve the same neighborhood.

Learners experiment with the microgrid station.

Materials Needed:

Neighborhoods:

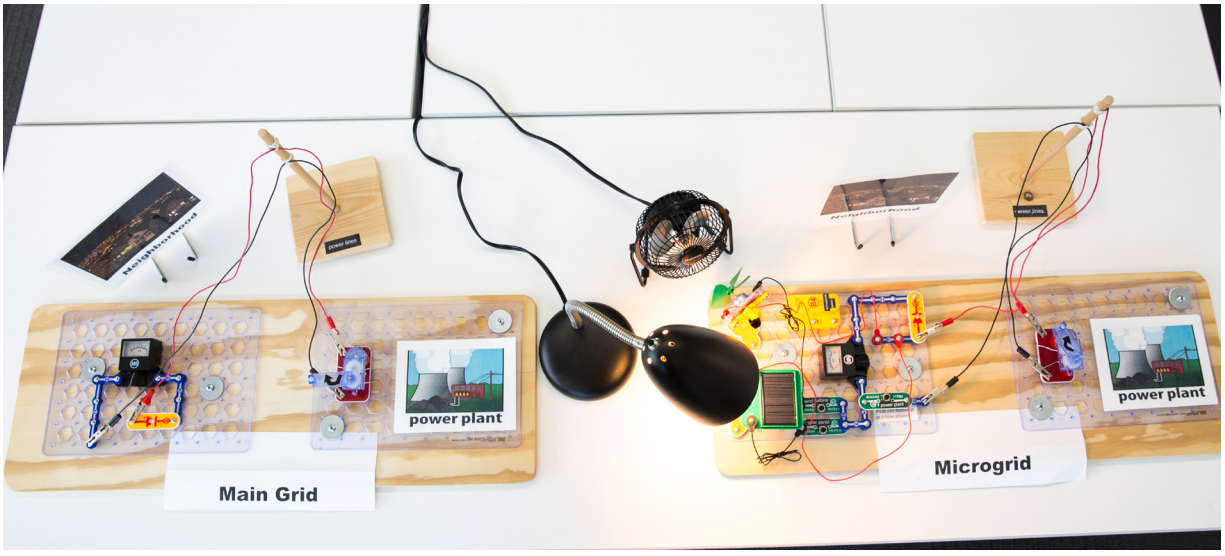
- "Snap Circuits Green Kit" by Elenco Company
- Additional "Snap Circuits" press switches (2): part #6SCS2
- Additional Snap Circuits large Base Gird (3): part #6SCBG
- Small tabletop fan (1)
- Small desk lamp (1)
- Snap Circuits 18" red jumper wires (2): part #6SCJ2
- Snap Circuits 18" black jumper wire (2): part #6SCJ1
- Access to electrical wall outlet

Power Lines:

- Two dowell rods 1/4" diameter, 12 " length
- Two 5 x 5 x 3/4 " wooden blocks
- Wood glue
- Four rubber bands
- Medium grit sandpaper

Materials for Optional Features:

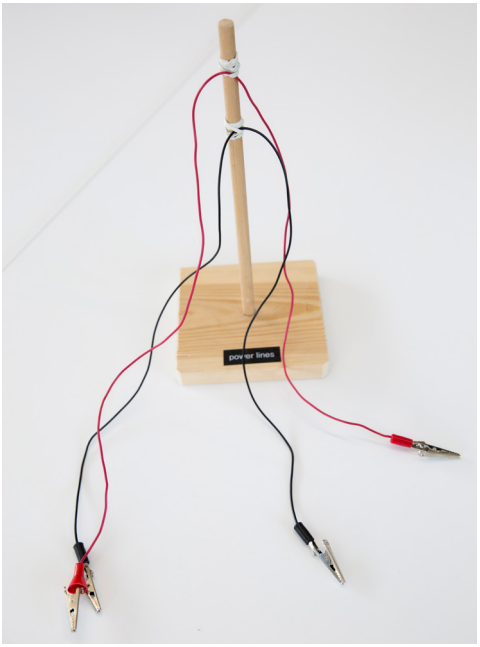
- Two 28x10x3/4" plywood mounting boards
- Four 1/2 " pan-head wood screws
- Four fender washers
- Wire cutters
- Small roll of 18 gauge aluminium wire
- Power strip
- Extension cord



The two grid options: the microgrid that generates and distributes power locally while still connecting to the main grid for back-up (right). The main grid connects the neighborhood to power that is generated far away (left).

Assembly:

The activity set-up includes two scenarios of a neighborhood: one powered by the main utility grid, represented by a hand-crank generator, and one powered by a microgrid, represented by a distributed generation schematic and back-up hand-crank generator.



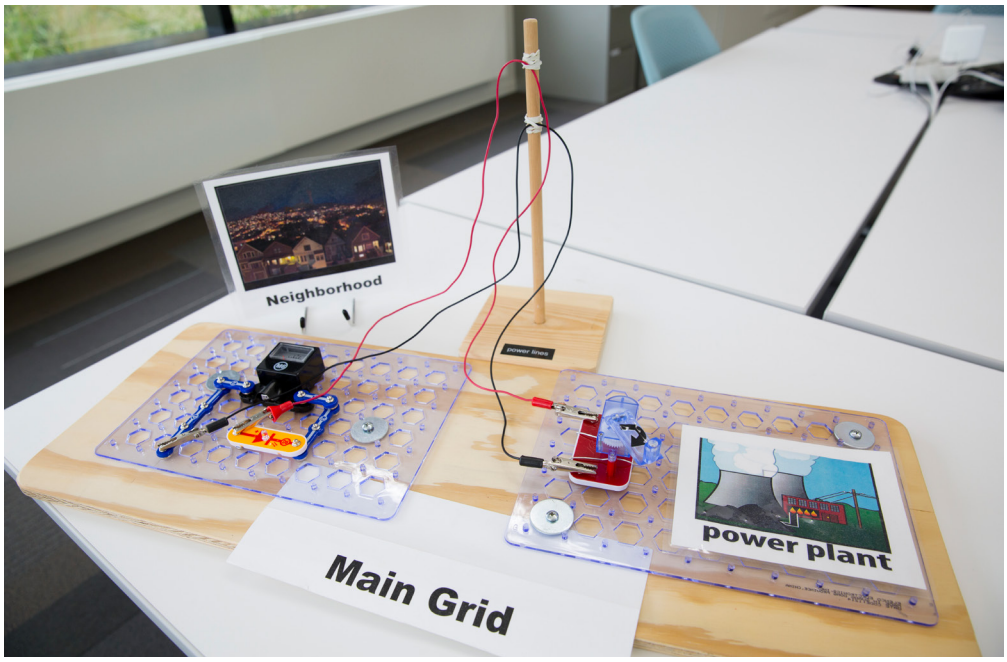
An example of the power lines.

Power Lines:

1. Sand the dowel rods and wooden blocks to prevent splinters.
2. Drill 1/4" hole in center of wooden blocks 1/2" deep.
3. Glue dowel rods in the holes in the wooden blocks.
4. Rubber band the jumper wires near the top of the dowel rod.

Main Grid Neighborhood:

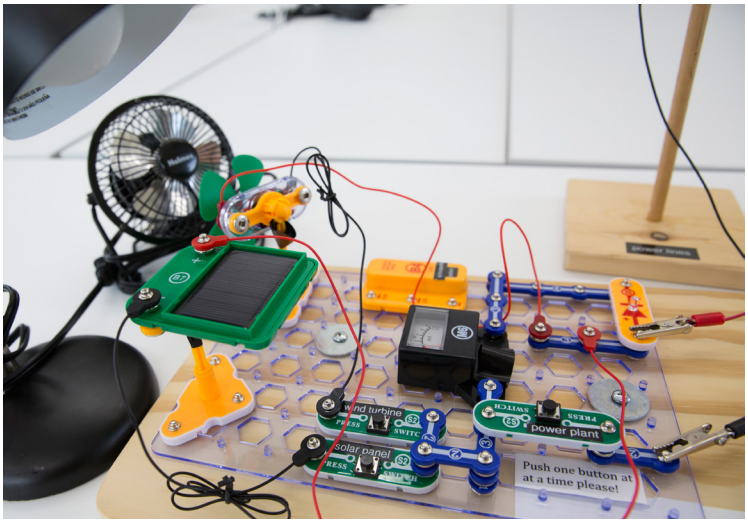
1. Snap hand-crank generator on plastic Base Grid. Use a 10" wire to wrap the crank generator to the board to hold it in place (optional).
2. Attach a label (included at the end of this document) next to the generator that says "power plant." Consider laminating labels for increased durability.
3. Mount analog meter and simple closed circuit with an LED to the plastic Base Grid using Snap Circuits components.
4. Use red and black jumper wires to attach the "power plant" board to the power lines.
5. Use red and black jumper wires to attach the main grid board to the power lines.

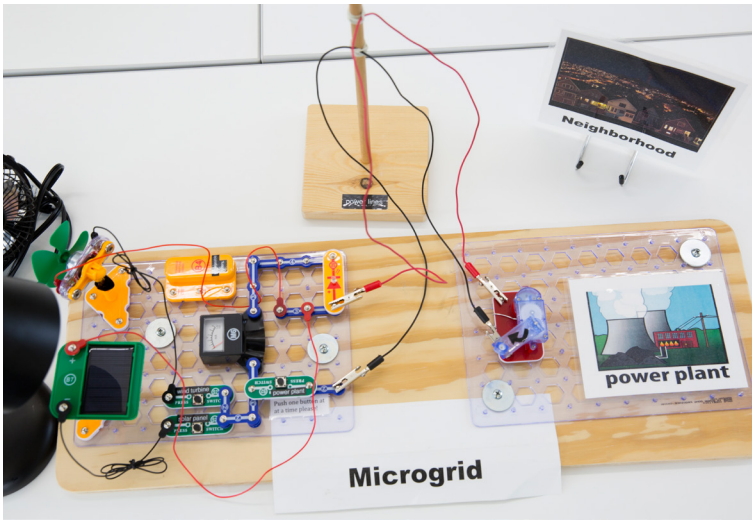


The main grid set-up. The power plant connects directly to the neighborhood.

Microgrid Neighborhood

1. Snap hand-crank generator on the plastic Base Grid. Use a 10" wire to wrap the crank generator to the Base Grid to hold it in place (optional).
2. Attach a label (included at the end of this document) next to the generator that says "power plant." Consider laminating labels for increased durability.
3. The microgrid assembly is a variation on a schematic provided in Snap Circuits Green Kit Project Book for project #10 "Multipower." To keep sources from interfering with each other, this activity uses additional press switches.
4. Attach the power lines to both the hand-crank generator and the "neighborhood" similar to the main grid set-up.





A close-up look at the microgrid neighborhood (left). The microgrid neighborhood is connected to the power plant as a backup source (right).

Optional

- Use two 28x10x3/4" pieces of plywood (sanded well to avoid splinters) to mount the "main grid" and "microgrid" scenarios. Drill 1/2" deep hole in plywood where the Base Grid is placed. Attach base grids to plywood using two pan head screws and fender washers per grid. This prevents components of the activity from sliding around on the table.

Guiding the Activity

The main message behind this activity is that there are other ways of generating and distributing electricity besides centralized power plants and long transmissions lines, and there are many reasons why reducing our reliance on fossil fuels is important. Begin facilitating the activity by asking some questions about power and electricity. Next, prompt the learner to crank the generator to simulate the generation of power for the main grid neighborhood. The learner will see that by cranking the generator, an LED lights up, representing power supply for the neighborhood.

***Note**: Be sure to use age-appropriate language and concepts, i.e. "electricity generation" is appropriate for high school students or adults, but "turning your lights on" would be better for a middle or elementary-aged student. Below are some sample questions to guide your dialogue.*

Introducing the Concepts: Sample Questions

- What is electricity?
- What is power?
- Do you know where your electrical power comes from?
- What do you use electricity for?
- Have you ever heard of fossil fuels?
- What makes the lights turn on at your house?

Transitioning from the Main Grid Neighborhood to the Microgrid Neighborhood

The next phase of the activity demonstrates that sources like solar panels, wind turbines, and batteries can also be used to power the microgrid neighborhood. Ask questions about power outages or other reasons why shifting away from centralized, fossil fuel-based power plants and long transmission lines is sensible. Then, simulate a tree or storm knocking out a distribution line by disconnecting your power lines from the microgrid neighborhood .The learner has to then think of new ways to "keep the lights on" in the neighborhood.

Sample Questions: Challenges to powering communities

- What happens if a tree falls on a power line?
- Should we be concerned about the smoke coming from the power plant?
- What happens when we run out of fossil fuels?

Manipulating Various Sources of Generation and Distribution

Allow the learner to hold switches and observe how the various renewable energy sources light up the LED, or "keep the lights on" in the microgrid neighborhood. Note: It is best if only one switch is pressed at a time. Doing otherwise could cause components of the system to break. While the learner manipulates the components, ask questions about renewable energy in terms of both benefits and challenges.

Renewable Energy: Sample Questions

- Have you heard of renewable energy?
- What are some sources of renewable energy?
- What are the benefits of renewable energy?

Extending the Concepts: Sample Questions

- What happens at night/ if it's cloudy during the day (relative to solar panels)?
- What happens if it isn't windy (relative to turbine)?
- What happens if we aren't making enough power with renewables (main grid as backup)?

Note for Educators:

This activity was created with consideration of the Next Generation Science Standards (NGSS). When used in conjunction with other activities and materials, this exploration station can help students achieve these NGSS:

HS ESS3-4 - Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

MS ETS1-1 - Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and using models Constructing explanations and designing solutions	**PS-3** Definitions of Energy **ETS1-1** Optimizing the design solution	Systems and system modeling Energy and matter

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