# Microgrid Technology Classroom Activity

## Activity Overview

A microgrid is a local, independent power grid. During storms or power outages a microgrid can separate from the utility grid and operate on its own using local energy generation. Fuel cells are one way to convert fuel into energy through a chemical process, rather than combustion. In this activity, students will examine benefits of microgrids and design a plan to incorporate a microgrid into their own community. Students will use local maps and data to determine the proximity of different sites to plan their centralized power system. As an extension, students will conduct an investigation to model how fuel cells convert chemical energy into electricity to explain how the microgrids are powered.

**Target Audience:** Middle School Students

**Activity Duration:** One class period (45-60-minute class session)

## Essential Questions

- What is a microgrid?
- What are the benefits of microgrids?
- What factors should be considered when planning to incorporate a microgrid into a community?
- How do fuel cells convert chemical energy into electricity?
- What advantage does a fuel cell have over other methods of powering a microgrid?

## Objectives

Students will:

- Understand the concept of microgrids within the context of energy generation.
- Examine the benefits of microgrids.
- Work in groups to design a plan to incorporate a microgrid into their community.
- Investigate how a fuel cell produces electrical energy through chemical reactions by conducting an electrolysis experiment. (Optional Extension)

## National Standards

- **ESS3.C: Human Impacts on Earth Systems**
  Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

- **ETS1.B: Developing Possible Solutions**
  There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.

**Materials**

Core Activity:

- Computers or other devices with Internet access
- Copies of KWL Plus Charts
- Copies of Microgrid Design Plan Graphic Organizer

Optional Extension:

- 400-mL glass beaker
- Two Double-Ended Alligator Clips
- 6-Volt Lantern Battery
- Two 6cm x 10cm Aluminum Foil Pieces (Electrodes)
- Tap Water
- Salt

**Procedure**

1. Ask students to complete the first two columns of the KWL Plus chart – “Know” and “Want to Know” – individually.

2. Invite students to watch the video

3. Encourage students to ask questions to clarify their understanding. Refer students to their KWL Plus charts to identify questions or areas for learning that were not answered by the video.

4. Direct students to briefly conduct additional research using the following guiding questions:
   - How do microgrids work?
   - What are the benefits of using microgrids?

   **Note:** Suggested resources include:
   U.S Department of Energy:
   http://www.energy.gov/articles/how-microgrids-work

Summary of the major benefits of microgrids can be found using the following link: http://interestingengineering.com/7-benefits-of-microgrids/
Article describing how the flexibility of microgrids makes it easier to incorporate renewable energy sources
https://ww2.kqed.org/quest/2014/07/23/microgrids-electricity-goes-local/

**Key points students should learn through the video and their research include:**

- A microgrid is a small-scale, flexible, and reliable source of energy
- Microgrids coordinate the use of local energy sources and allow local power grids to maintain necessary levels of service in event of extreme demand or substation failure.
- Wind/solar power may be used in conjunction with diesel generators to regulate the required frequency for a microgrid and manage fluctuations
- Some of the benefits of microgrids include:
    - Increased resiliency
    - Providing a backup power source that can be used during a grid outage
    - Aiding economic growth though job creation
    - Reducing the environmental impact through the use of renewable energy or low emissions technologies.
- Some factors to consider when planning to incorporate a microgrid into a community include:
    - Choice of site (based on population size, proximity to existing infrastructure, etc.)
    - Minimizing cost and emissions
    - Choice of power to meet energy demands and reliability for customers
    - Ways to protect the system from harmful effects (such as short circuits, natural disasters, etc.)
- Fuel cells consist of many stacks of individual cells made up of electrodes (anodes/cathodes) and electrolytes. Hydrogen-rich fuel reacts electrochemically with oxygen to produce an electric current, heat and water. Fuel cells continuously generate electricity as long as fuel is provided. Unlike traditional batteries, they do not have a fixed supply of energy
- There are four primary fuel cell technologies: carbonate, solid oxide, phosphoric acid, and polymer membrane (PEM). Each type is suited for specific small-scale and large-scale applications
- Fuel cells make much more efficient use of fuels than other distributed generation technologies and they are low emission
- Fuel cell power plants can be designed to run independently off the electric grid

5. Instruct students to complete the “Learn” portion of their KWL Plus chart individually. Give students the opportunity to Think-Pair-Share with a partner and then add to the “Learn” segment of their chart following their discussion.

6. Explain to the class that they will be designing a plan to incorporate a microgrid into their own community. They will use additional online resources (including local maps and data) to complete the graphic organizer in small groups. Students will need to work together to determine solutions for the questions posed and provide explanations for

their choices. When selecting their location they should consider including areas that would be most impacted by a power outage, such as hospitals and grocery stores.

The following resources can be used for narrowing down a site for the microgrid:

- http://maps.google.com and http://data.mapmart.com/htmlpages/map.html
  - Can be used to search for a specific location and the surrounding areas. Students should focus on key geographical features, such as how open the area is, its proximity to water, closeness of the buildings, susceptibility to outside threats, etc.

- **http://www.census.gov/topics/population.html**
  - U.S. Census Population Data provides information on household income and population density.
- Also have students search for data from power suppliers or news media about power outage frequency or response time to restore power after emergencies.
  - For example, some providers have searchable outage maps by area code that include the number of active outages and affected customers.

7. Allow each group to present various facets of their design plans. Each should create their "elevator pitch," or what they would say to a policy maker who has the power to approve their microgrid project if they were stuck in an elevator with him or her for two minutes. This will encourage them to highlight the most essential points of their plan.

8. Engage students in a whole class discussion of the pros and cons of the solutions presented. Ask them to consider which plan would have the greatest likelihood of success and why? Facilitate the discussion by asking questions to help students develop and provide evidence for their conclusions.

9. Direct students to complete the "Plus" section of their KWL Plus chart to reflect the things they still would like to learn about microgrids, fuel cells, and/or other forms of energy capture or generation.

**Optional Extension**

Students can conduct an experiment in which they produce hydrogen through the electrolytic decomposition of water into hydrogen and oxygen gas. This investigation models how fuel cells convert chemical energy into electricity to explain how the microgrids are powered. A basic electrolytic cell is prepared using a beaker of water, wires, electrodes, and a direct-current power source. The added salt acts as a catalyst by increasing conductivity and speeding up the reaction. The gases produced in the reaction can be collected using inverted test tubes and the water displacement method. The experimental procedure is available through the *U.S. Department of Energy Hydrogen and Fuel Cells Middle School Activity Guide* (pages 45-62).

The Electrolysis Student Activity Sheet is found on page 51. The teacher's guide is available on pages 55-57. Below is the link to the complete PDF:

http://www.nrel.gov/education/jss_hfc.html

**Note:** Some post-lab questions for the Electrolysis Lab are included at the end of that lesson. The most important ones to consider are: Which ions are responsible for charge flow in the electrolysis circuit? What is the purpose of adding salt to the water in this experiment? What observation allows you to determine that a gas is produced at the electrodes? and What process occurs at each electrode (cathode and anode)?

**Additional Resources**

- Types of Fuel Cells
  http://energy.gov/eere/fuelcells/types-fuel-cells

- Two-Part Series Microgrid – NPR
  http://www.marketplace.org/2015/06/19/sustainability/weak-link-state-infrastructure/backing-power-grid-homemade-electricity

- Additional Microgrid Activity:
  https://energy.wisc.edu/sites/default/files/educational-materials/Microgrid%20Sustainable%20Energy%20Exploration%20Station.pdf

NAME: _____PERIOD _____ DATE _____

| MICROGRIDS & FUEL CELLS | | | |
|---|---|---|---|
| **K** | **W** | **L** | **+** |
| What do you **KNOW** about the topic? | What do you **WANT** to know about the topic? | What did you **LEARN** about the topic? | What do you **STILL** want to learn about the topic? |

NAME(S): _____ PERIOD _____ DATE _____

## MICROGRID DESIGN PLAN CONSIDERATIONS

| HOW WILL YOU? | DESCRIBE AND EXPLAIN YOUR APPROACH |
|---|---|
| **Choose a Site (Based on Population Size, Proximity, Etc.)** | |
| **Minimize Cost** | |
| **Protect the Environment: Minimize Emissions** | |
| **Power the Microgrid** | |
| **Meet Energy Demands & Reliability of Service for Customers** | |
| **Protect the System from Harmful Effects (Example: Short Circuits, Natural Disasters, Etc.)** | |