CURENT

Powering VOLt City

CURENT is a National Science Foundation and U.S. Department of Energy funded Engineering Research Center.

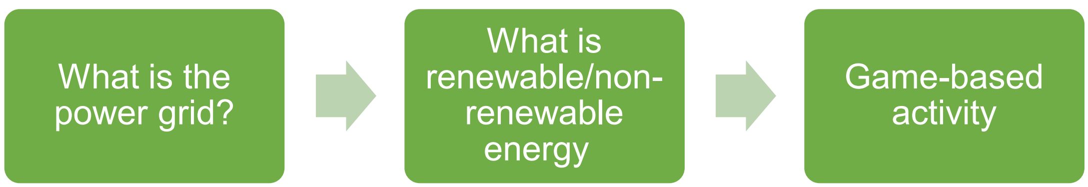
Powering VOLt City

Activity appropriate for students grades 3-8

Parents: We know that it's been a while since you learned many of these concepts. We've included background information to help you answer the questions that will come up as you do this activity. If you need more information or have questions, please email education@curent.utk.edu and we can help.

Overview:

This is an introductory lesson on different ways electricity is generated in the power grid, as well as the social and economic considerations that should be remembered when we talk about power and renewable energy.



Vocabulary:

- **Generation:** Process of creating electric energy by transforming other forms of energy into electricity.
- **Transmission**: Is the bulk movement of electricity from a generation site to a substation.
- **Distribution**: Is the last step in electricity transportation, when it is supplied to individuals.
- **Generator**: A machine that changes mechanical energy to electrical energy.
- **Transmission Lines:** A line used to transport the electricity for long distances.
- **The Power Grid** : Is the system of producers and consumers of electricity
- **Current:** The flow of charged particles (electrons) through any medium.
- **Voltage:** The force that is causing the flow of current.
- **Substation:** The location where the voltage is transform to a lower and safer level for distribution.
- **Transformer:** A machine that can raise or lower the voltage level depending on what is needed.

CENTER FOR ULTRA-WIDE-AREA RESILIENT ELECTRIC ENERGY TRANSMISSION NETWORKS

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BACKGROUND INFORMATION

The grid is the web of power lines that span across modern civilizations and everything that is connected to them. This system is what connects the power generated at power plants to the power outlets in your home.

There are three parts, or interconnections, that make up the North American grids:

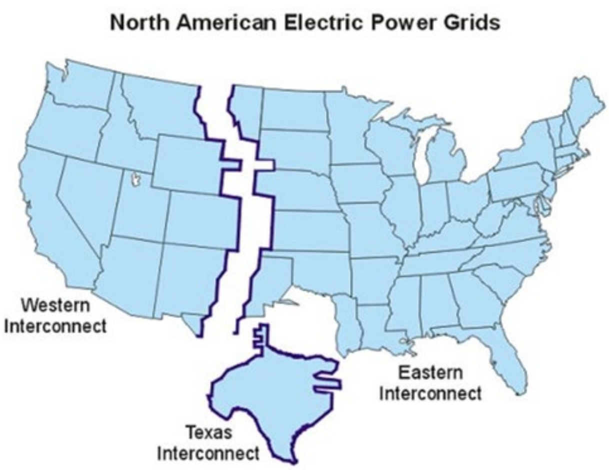

Figure from EPA website

Eastern Interconnection: East Coast and parts of Canada
Texas Interconnection: Just texas
Western Interconnection: Western parts of the US and parts of Mexico

For more information on the grid, please visit the following resources:

https://www.epa.gov/greenpower/us-electricity-grid-markets
https://www.epa.gov/greenpower/us-electricity-grid-markets

The grid can be broken down into 4 components:

Generation, of which there are two types:
A) **Centralized**: Large-scale power generation including coal, nuclear, hydro, wind and solar farms.
B) **Decentralized**: Small-scale generation where most or all of the power generated is used by the residents or property owner (ex. solar panels on a home's roof).

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Transmission: Lines connect the power created in the generation stage to substations, located in areas around its destination, which operator at extremely high voltages (usually between 69kV - over 700kV). However, power is not generated at this high voltage. It is typically generated at less than 25kV. In order to increase this voltage, the power is sent through a **step-up transformer.** This will increase the voltage at the loss of current which allows the power to be transmitted with a higher efficiency through the transmission line as it travels long distances

Distribution: The substations at the end of the transmission lines will then lower, or "step down," the voltage to be between 2.3kV and 34.5kV using **step-down transformers**. Once the voltage has been lowered, the power is sent through distribution lines to its destination. These distribution lines are the power lines that you see around your home, school or work.

Consumption: As the name implies, this is the part of the grid where power is consumed. The power will run through one last transformer mounted on a power pole close to its final destination that lowers the voltage to 120V. It is then run to wherever it is needed such as a wall outlet or the lights in a building.

Name:______________________________

How Electricity Gets to your Home

When you plug something into a wall outlet to charge it at night, the power you're using may have come from hundreds of miles away, or even from a different country! But how does it get to your home? Electricity travels from source to destination in three major steps: Generation, Transmission, and Distribution.

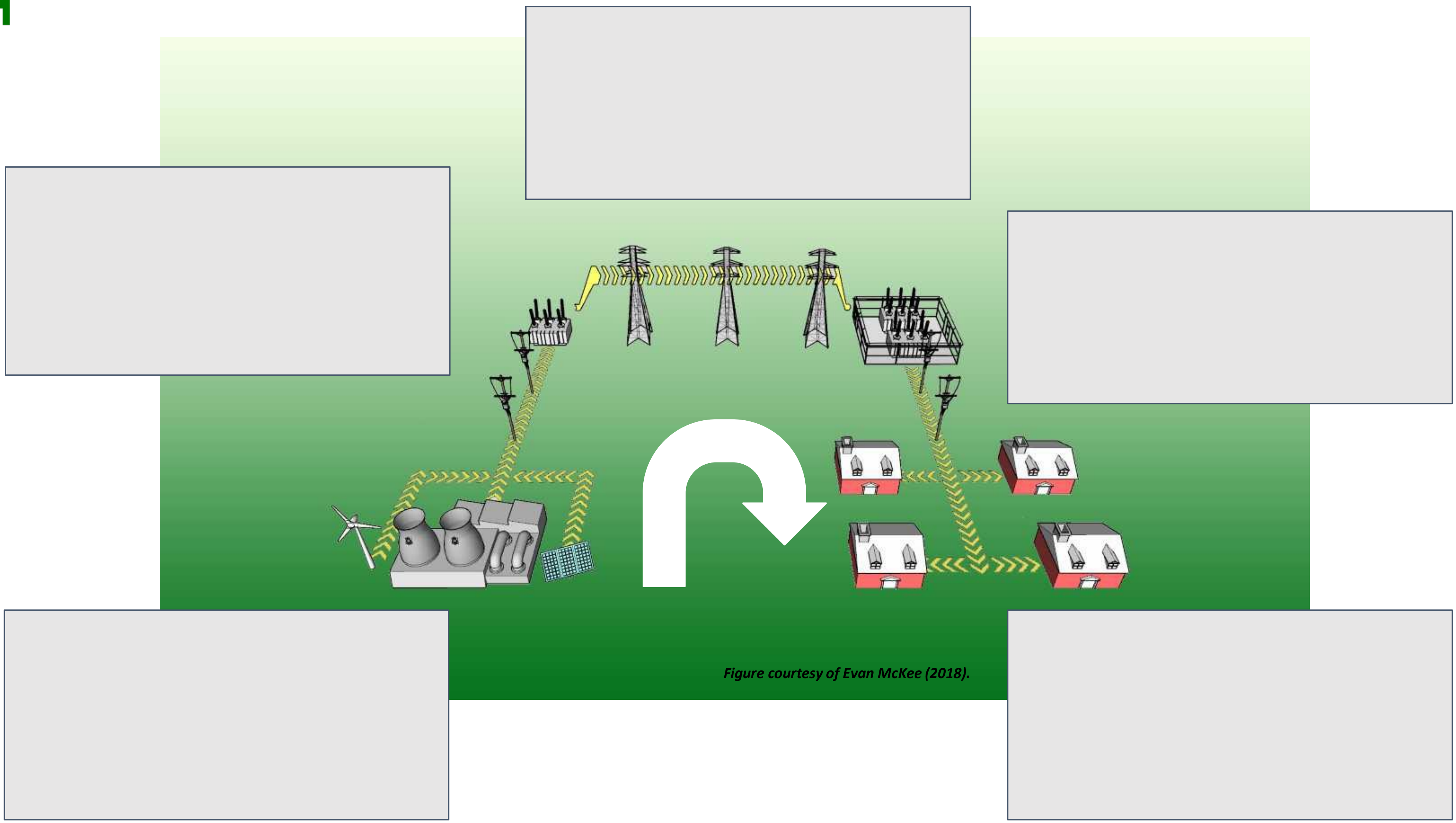


Figure courtesy of Evan McKee (2018).

Name:_______________________________

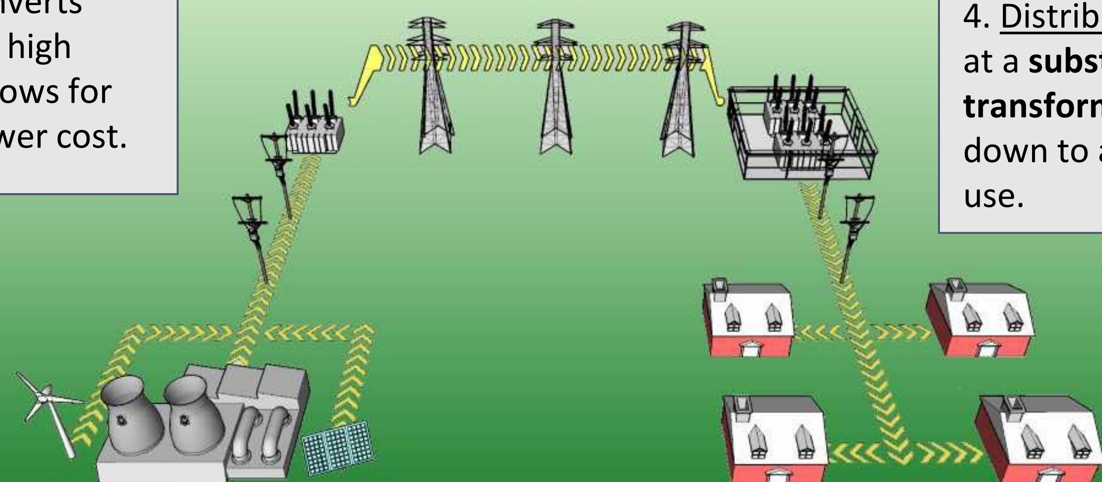
How Electricity Gets to your Home (Answer Sheet)

When you plug something into a wall outlet to charge it at night, the power you're using may have come from hundreds of miles away, or even from a different country! But how does it get to your home? Electricity travels from source to destination in three major steps: Generation, Transmission, and Distribution.

3. Transmission: During **transmission**, electricity can travel for hundreds of miles across high voltage metal poles.

2. Before the power is transmitted, a **step-up transformer** converts the electricity from low to high voltage. Higher voltage allows for lighter power lines and lower cost.

4. Distribution: Distribution begins at a **substation**, where **step-down transformers** bring the voltage down to a safe level for household use.



1. Generation: Power sources like this **windmill**, **nuclear plant**, and **solar panel** harness the earth's resources to generate electric power.

Figure courtesy of Evan McKee (2018).

5. Smaller wooden telephone poles send electricity out to individual homes, and connect to a control panel in your home's garage, basement, or closet.

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Energy that is generated comes from different sources.

We say energy is **renewable** if it is almost endless – that is, we can always find some when we need it. Examples of renewable energy include wind, solar, water (hydroelectricity), geothermal and biofuel. This energy is often **clean** energy, or green energy, in that there is usually no population created by using this energy source.

We save energy is **non-renewable** when it has a limited supply. Examples of nonrenewable energy include coal, natural gas, and other fossil fuels. These forms of energy are not green, or clean, because they create pollution.

Nuclear energy is in-between: it is clean energy because nuclear power plants do not create pollution, but there is a limited amount of uranium in Earth's soil.

Powering VOLt City activity:

1. Print out the VOLt City map (we recommend printing on multiple pieces of paper and then taping them together).
2. Print and cut out the power sources.
3. Follow the directions on the VOLt City worksheet and calculate the load, or amount of power that will need to be generated based on the demands of VOLt city. Then, start considering what power types to use, where to place them, and how to stay on budget.

Name:_______________________________

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Congratulations, you're hired!

VOLt City needs an ENGINEER to redesign its power systems. Luckily, the environment around VOLt City has many nonrenewable and renewable resources to provide power.

Step 1 ASK: Identify the need or Problem: How much power will you need to supply?
Find the total by adding up the megawatts from the chart below.

Who needs power?	How much power? (in megawatts)
School	1
Mall	30
Sports Stadium	15
Neighborhoods	4
Downtown	40
Total	

Step 2 ASK: Research the need or problem: Consider the constraints for the power systems project you will design. They are listed below.

1. **Every project has a budget. For this project, your budget is $500 million dollars.**
2. **The cost to run a power plant depends on the source of the power.**
3. **Certain power sources produce more power than others.**
4. **Some power plants produce pollution that can harm the environment.**

Step 3 IMAGINE: What kind of power would you want VOLt City use? Circle one of the choices below.

renewable both non-renewable

Name:______________________________

Step 4 PLAN: What resources will you use to power VOLt City?

How much is your budget? $___________________________________ million dollars.

How much power do you need to generate? _________________________ megawatts.

Power Generation	Energy generated in Megawatts	Cost in millions of dollars	Environmental Effects
Solar Farm (Photovoltaic)	5	50	No toxic pollution or emissions Land used (habitat loss)
Wind Turbines	10	60	No toxic pollution or emissions Land used (habitat loss) Some sound produced
Hydroelectric (Dam)	15	50	No toxic pollution or emissions Land used (habitat loss) Changes aquatic ecosystems
Nuclear Power Plant	15	50	Very small emissions 1-2 tons radioactive waste Very little air and water pollution Needs to be near a body of water Takes longer to turn on and off
Coal Power Plant	15	25	Large amount of toxic emissions Air and water pollution Land used (habitat loss) Needs to be near a body of water Health effects of workers and community members
Natural Gas Plant	15	60	Large amount of toxic emissions but 50% less emissions than coal Air and water pollution Land used (habitat loss) Needs to be near a body of water

Name:______________________________

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Step 5 CREATE: What resources will you use to power VOLt City? Fill in the table below with the power systems VOLt City will use.

Power Generation	**Energy Generated in Megawatts**	**Cost in millions of dollars**	**Environmental Effects**
Total:			

Name:______________________________

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Step 6 IMPROVE: Improve/Change/Reflect
How do you think your power plants will affect the community?

Did you have any money left over after buying the power plants? How could VOLt City use that money for to improve the community?

What would you change to make your power generation plan for VOLt City better?

Name:______________________________

Creating the VOLt City Power Grid

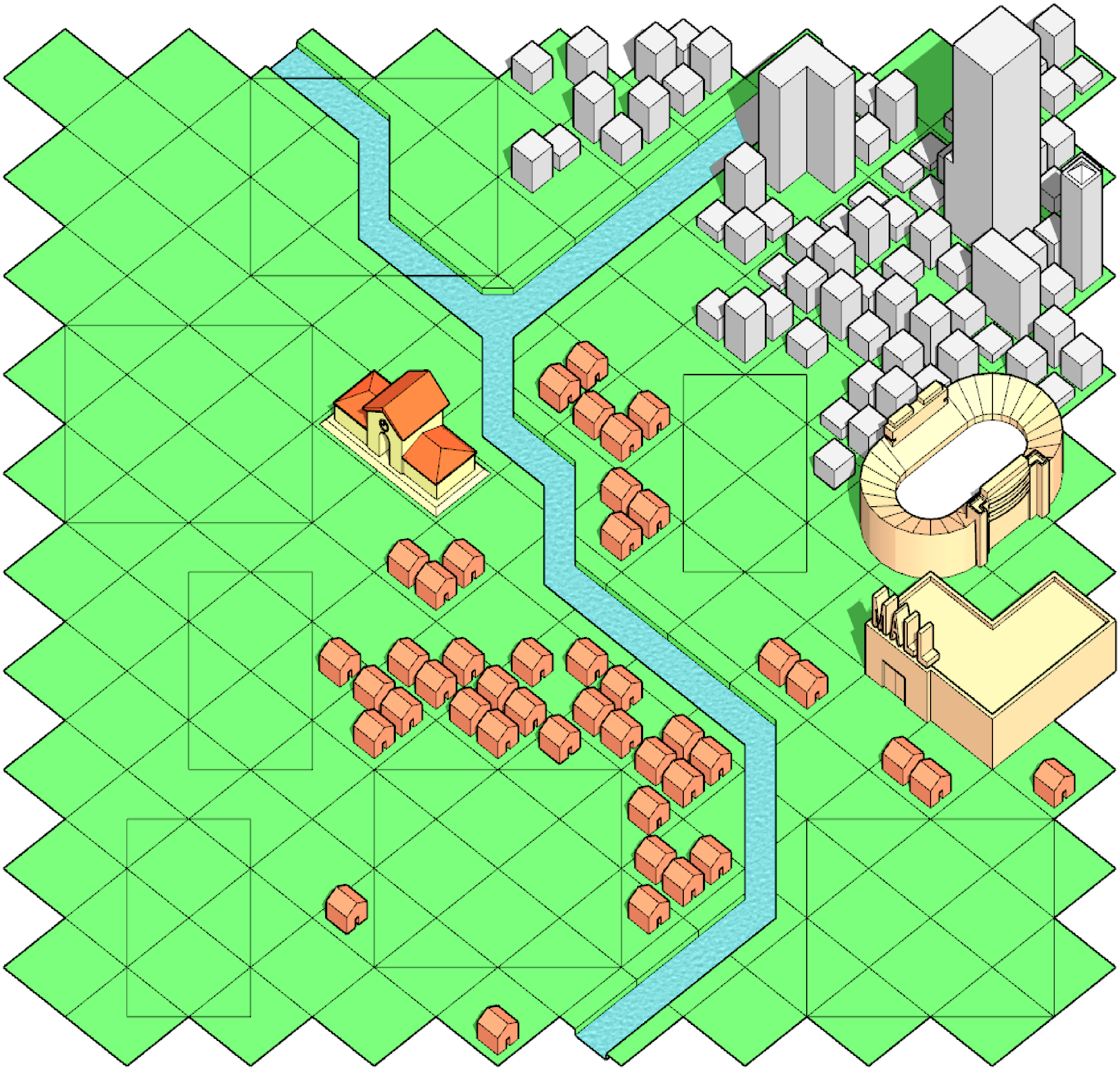
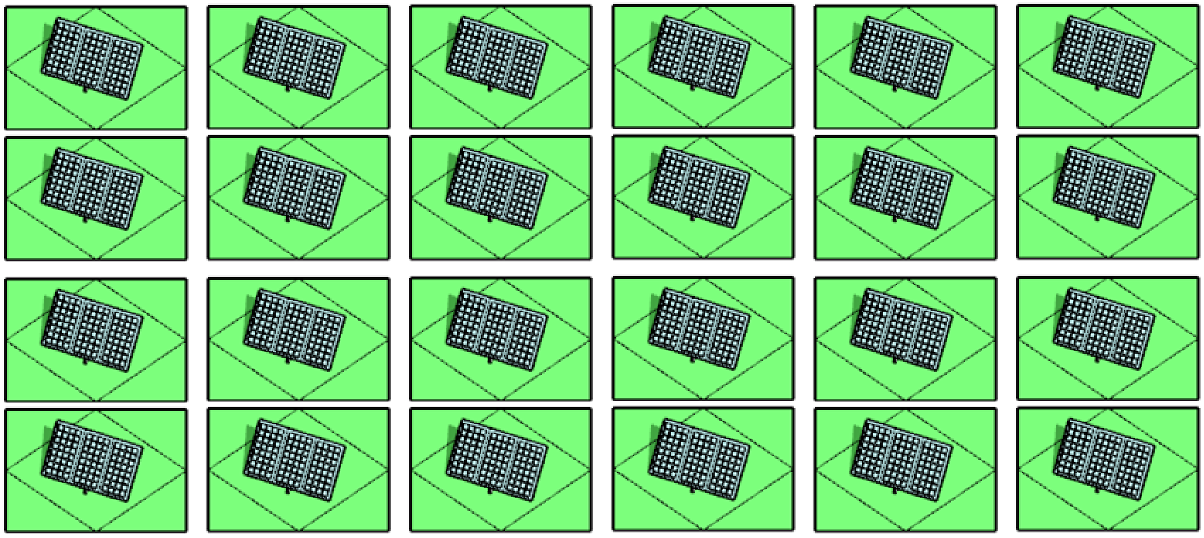


Figure courtesy of Evan McKee (2018).

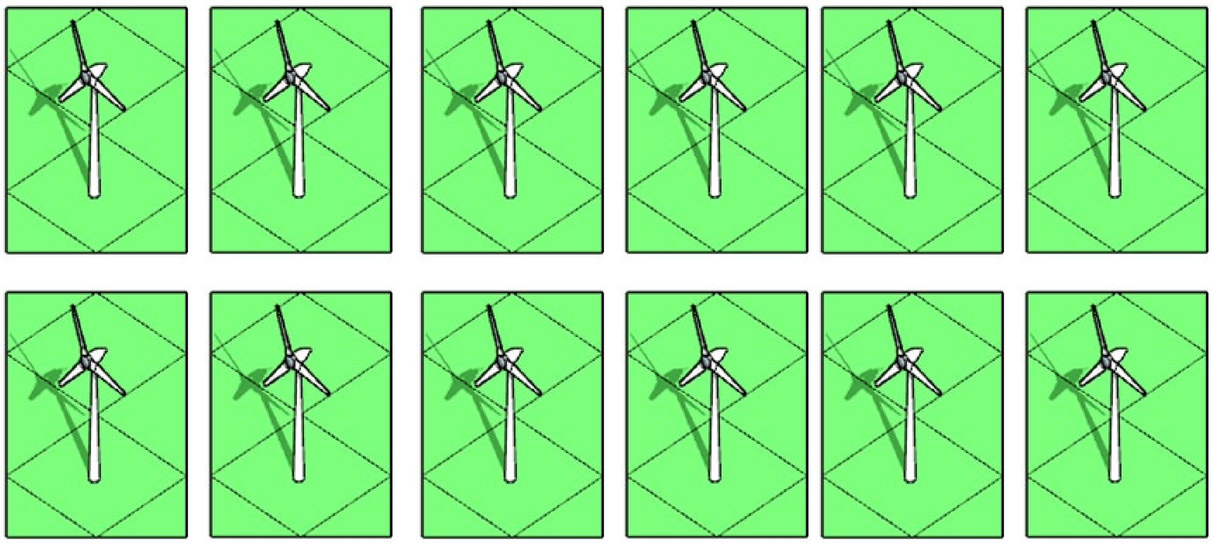
Cut-outs: VOLt City Power Grid

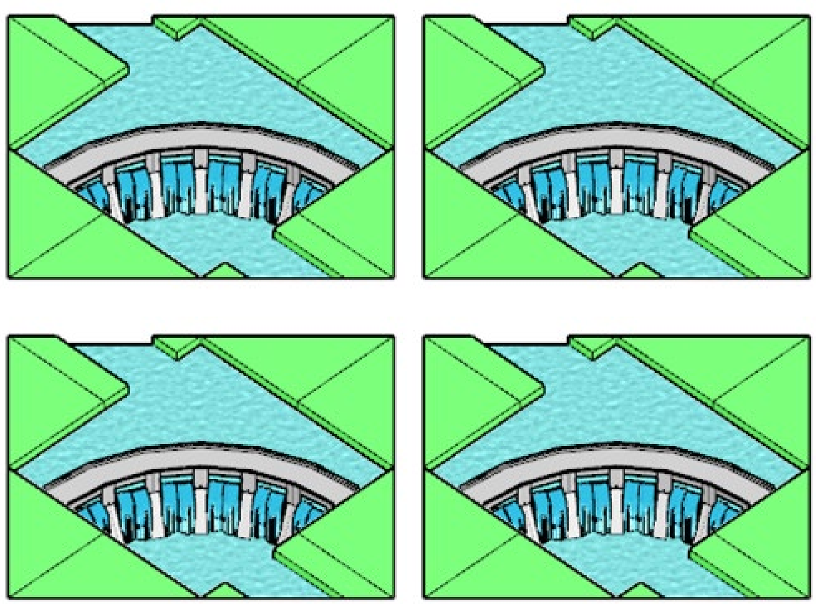
Solar farms



Figures courtesy of Evan McKee (2018).

Wind farms and hydro (below)





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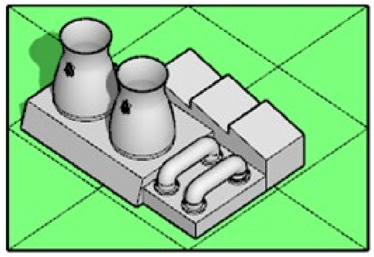
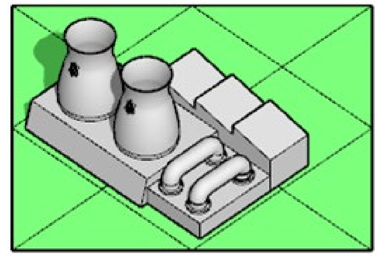
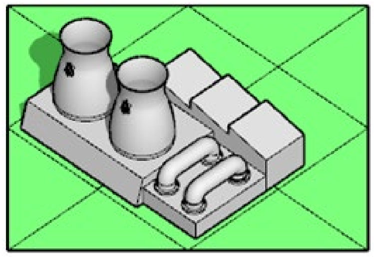
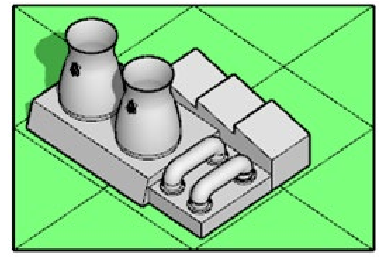
Cut-outs: VOLt City Power Grid

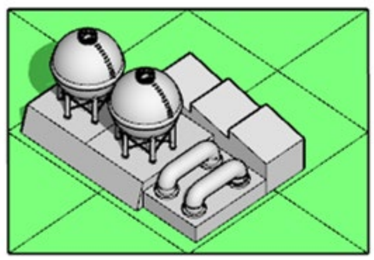
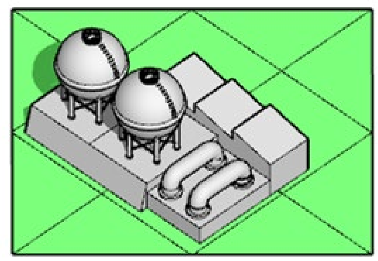
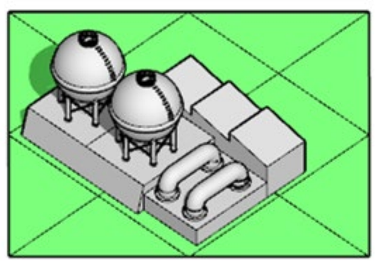
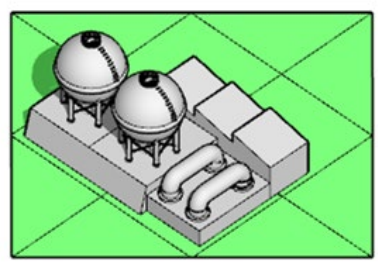
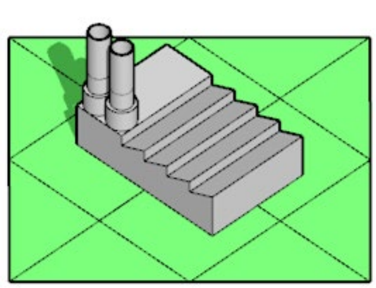
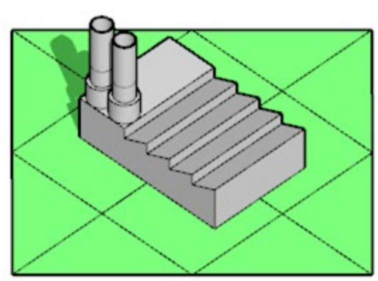
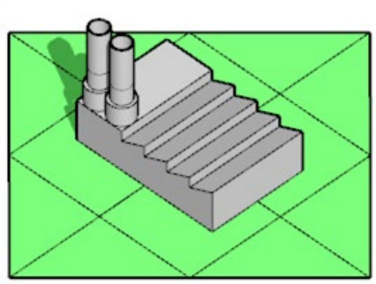
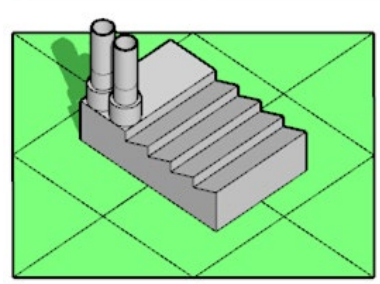
On this page:
4 nuclear power plants

4 natural gas plants

4 coal plants

Figures courtesy of Evan McKee (2018).

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Additional Modifications for middle school students:

- Have them look at the websites provided on the first page about the three interconnections.
- See if you can find where your local utility provider gets their energy. For example, in Knoxville TN (where CURENT's headquarters are located), we have the Tennessee Valley Authority (another possible extension might be to look up TVA history and discuss) and our local utilities like Knox Utility Board are provided energy from TVA, which uses a combination of natural gas, hydro-electricity, nuclear, and some coal.
- When planning where to put the various power types, have students think about the possible social and economic benefits and deficits of location. For example, would it be a good idea to have a pollution-heavy coal plant near a school? A solar farm in a downtown region with tall buildings (this could be good or bad – you could sell back the power to the utility if you put solar panels on buildings, but not on the ground where the sun could be blocked by the buildings).