Dear teachers and students,

The Minnesota Municipal Power Agency (MMPA) is excited to host you and your classroom at this year’s Energy Education Event! MMPA supports energy education in the communities we serve. Our Energy Education Program demonstrates the Agency’s commitment to provide educational resources about energy for schools in its member communities and project host communities.

Since its inception, MMPA’s Energy Education Program has reached over 15,000 students in MMPA member communities and project host communities through its Faribault Energy Park tour events and in-school assemblies. In addition, the Hometown Solar installations have also supported energy education in the member communities of Anoka, Arlington, Brownton, Chaska, East Grand Forks, North St. Paul, Olivia, Shakopee, and Winthrop.

This workbook supports our elementary program and aligns with Minnesota’s 4th grade science standards. It is intended to be used as an educational tool that is completed prior to your Energy Education Event. The workbook covers a variety of energy-related topics, including:

- Introduction to Electricity
  Learn about the basics of electricity and explore how you use electricity on a daily basis
- Energy Sources Used to Produce Electricity
  Review the different energy sources (non-renewable and renewable) used to generate electricity
- The Power of Your Hometown, Where Your Electricity Comes From
  Understand where your electricity comes from through an introduction to MMPA & your local municipal utility
- How a Power Plant Generates Electricity: MMPA’s Faribault Energy Park
  Discover how power plants, such as Faribault Energy Park, generate electricity that is delivered to homes and businesses
- Energy Conservation
  Complete take-home activities that encourage students to better understand their energy usage and learn ways to conserve energy at home

For more information on Energy Education or MMPA, please visit mmpa.org.

We look forward to seeing you!

Sincerely,
The Minnesota Municipal Power Agency
What is Electricity?

Questions for My Energy Education Event:

<table>
<thead>
<tr>
<th>What I Know</th>
<th>What I Want to Know</th>
<th>What I Learned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Energy is the ability to do work. Energy can take a number of forms. Example forms of energy include electrical, chemical, mechanical, thermal, light, and nuclear. Energy cannot be created or destroyed; it can only be transformed from one form of energy to another. This Energy Education Workbook focuses on electrical energy, or electricity.

Electricity is one of the most common forms of energy that we use and can be produced from a variety of energy sources. These energy sources are often divided into two categories: non-renewable (conventional) and renewable. Example sources of energy used to produce electricity include: natural gas, wind, coal, solar, nuclear, geothermal, hydro, and biomass.

Once electricity is produced, it can be transported many miles over electric power lines and delivered to homes and businesses for daily use. Common uses of electricity include: lighting, heating and cooling, and powering of basic household items such as appliances, computers, etc.
What is Electricity?

Everything in the universe is made up of atoms. Atoms are made up of small particles called protons, neutrons, and electrons. Electricity is defined as the movement of electrons. When electrons flow through conductors (such as copper wire) they form an electrical current. Electrical current provides the energy we need to power various things - lights, computers, electric vehicles, etc.

Measuring Electricity

There are a lot of terms used to describe the measurement of electricity. You may have heard words such as watts, watt-hours, kilowatt-hours, or megawatt-hours. A watt is a unit used to measure electricity production or consumption. A watt-hour measures that same electricity over a specified period of time.

A common household light-emitting diode (LED) bulb uses 10 watts of electricity. If you leave a 10-watt light bulb on for one hour it will use 10 watt-hours of electricity.

To measure large amounts of electricity we use kilowatts (kW) and megawatts (MW). Kilo means thousand (one kilowatt is equal to 1,000 watts). Mega means million (one megawatt is equal to 1,000,000 watts).

Example: Faribault Energy Park (FEP) is a 300 MW power generation facility.

<table>
<thead>
<tr>
<th>Watts</th>
<th>Kilowatts</th>
<th>Megawatts</th>
</tr>
</thead>
<tbody>
<tr>
<td>300,000,000</td>
<td>300,000</td>
<td>300</td>
</tr>
</tbody>
</table>

FEP has the capacity to power 30,000,000 (10-watt) LED bulbs.
- (300,000,000 watts / 10 watts = 30,000,000 LED bulbs)

My Electricity Usage

Electricity is part of our everyday lives. We use it, but we often don’t think about how much we use or where it comes from. To better understand your electricity usage, complete the exercise below:

How I Use Electricity at Home
List examples of ways you use electricity in the following spaces:

<table>
<thead>
<tr>
<th>Kitchen:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.</td>
<td>2.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Living/Family Room:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.</td>
<td>2.</td>
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</table>

<table>
<thead>
<tr>
<th>Bedroom:</th>
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<tr>
<td></td>
<td>1.</td>
<td>2.</td>
</tr>
</tbody>
</table>

Review the ways you use electricity (listed above) and answer the following questions:

- What items do you think use the most electricity at your home?

- How could you use less electricity (list 3 ways)?
  1. 
  2. 
  3. 

How I Use Electricity at School
List three ways you use electricity at school:

1. 
2. 
3. 

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Electricity can be produced from many different energy sources and processes. Some energy sources that are used to make electricity are outlined below. These energy sources are commonly divided into two groups: Non-Renewable (Conventional) and Renewable.

**Non-Renewable (Conventional)**
Non-renewable energy sources generate the largest portion of electricity in the United States. These energy sources are considered to be in limited supply as they will eventually run out or are unable to be replenished (made again) in a short period of time. Non-renewable energy sources produce electricity using the processes outlined below:

- **Natural Gas** is extracted from the earth, treated, and combusted to produce electricity.
- **Coal** is extracted from the earth and burned to produce electricity.
- **Oil** is removed from the ground, refined, and burned to produce electricity. This resource is often used in remote areas.
- **Nuclear energy** uses the energy from splitting atoms in a process called nuclear fission to produce electricity.

Natural gas, coal, and oil are fossil fuels. Fossil fuels were formed millions of years ago. Heat from the earth’s core and pressure from rock and soil turned the remains of many dead organisms (or “fossils”) into natural gas, coal, and oil.

**Renewable**
Renewable energy sources come from natural resources and can replenish over relatively short periods of time. Renewable energy sources generate electricity in the following ways:

- **Solar energy** uses heat and light from the sun to produce electricity.
- **Wind energy** harnesses energy from the wind to produce electricity.
- **Geothermal energy** uses heat from the earth to produce electricity.
- **Hydropower** uses the energy of falling or running water to produce electricity.
- **Biomass energy** uses materials such as wood, solid waste (garbage), food processing and agricultural waste to produce electricity.

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**Questions for My Energy Education Event:**

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<th>What I Want to Know</th>
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</tbody>
</table>
Energy Sources Activity

Directions: Draw a line from the picture of the energy source on the left to the description that matches it on the right.

- Wind turbines harness energy from the wind to produce electricity.
- This fossil fuel is extracted from the Earth via surface or underground mining and used to produce electricity.
- Agricultural waste, such as corn silage, is used to produce electricity.
- This fossil fuel is extracted from the earth, treated, and combusted to produce electricity.
- Energy from the sun is harnessed using solar panels to produce electricity.
- When atoms split apart, they release energy that can be used to produce electricity.
- Energy from falling or running water is harnessed to produce electricity.
- Heat from the earth is used to produce electricity.
- Machines remove this fossil fuel from the ground so it can be refined and burned to generate electricity.

The Power of Your Hometown: Where My Electricity Comes From*

* MMPA Member Communities
MMPA has a diversified portfolio of owned and purchased generation containing both conventional (non-renewable) and renewable resources. This means our communities have access to a mix of energy resources. This approach allows the Agency to maintain flexibility in the rapidly-changing electric utility industry and positions the Agency well for the future.

MMPA provides wholesale electricity to its 12 member municipal utilities. Your local municipal utility delivers and sells that electricity to the residential and business customers in your community.

HOW POWER GETS TO YOUR HOME

1. MMPA’S POWER SUPPLY

MMPA’s power supply includes a mix of conventional and renewable energy sources. The image shows various power plants and wind farms that contribute to the Agency’s energy portfolio.

2. OUR MEMBER MUNICIPAL UTILITIES

MMPA’s wholesale electricity is provided to its 12 member municipalities.

3. POWERING YOUR HOMETOWN

Your local municipal utility delivers and sells electricity to residential and business customers in your community.
How a Power Plant Generates Electricity: Faribault Energy Park

Faribault Energy Park (FEP)

Technology:
- Dual-fuel (natural gas and fuel oil); combined-cycle

Capacity:
- 300 MW

Location:
- Faribault, MN

Commercial Operation Date:
- August 2007

FEP Features
- Largest municipally-owned power plant in Minnesota
- Combined-cycle plant with a second generator powered by waste heat
- Efficient and low emissions
- On-site solar and wind power generation to support Agency’s Energy Education Program
- March 2008 cover story of Power Magazine

Not Just a Plant but a Park...
Completed in 2007, Faribault Energy Park meets the region’s growing need for energy. But when MMPA developed the concept of creating a plant as a community asset, the goal was to accomplish much more than that. FEP is an integral part of the local community by providing education, recreation, and aesthetic beauty. Students and area residents are welcome to visit the facility’s 35 acres of park-like wetlands and walking trails. In addition, guests are encouraged to schedule tours of the facility that include viewing the control room and the steam turbine from an observation area. Visitors can also view educational displays, a wind turbine, a solar array, and can even drop a fishing line into one of the ponds.
How FEP Generates Electricity:

Faribault Energy Park (FEP) is a combined-cycle power plant. A combined-cycle power plant uses both natural gas and steam to produce electricity. At FEP, the excess heat from the gas turbine is used to power a steam turbine, generating more electricity without any additional fuel. Learn more below:

1. Air and natural gas (fuel) are combined and burned. The heat and pressure from the combustion expands and pushes against the gas turbine blades.

2. The turbine blades are connected to a drive shaft that spins the electric generator and produces electricity.

3. The heat created by the gas turbine is used to make steam in a heat recovery steam generator (HRSG).

4. The steam and pressure created in the HRSG are then used to turn the steam turbine blades and its electric generator. The steam turbine produces additional electricity without using additional fuel.

Faribault Energy Park is a 300 MW Facility:

~ 185 MW is generated from the gas turbine
~ 115 MW is generated from the steam turbine, without any additional fuel.

The average home in Minnesota uses 8,976 kilowatt-hours per year.* If FEP produced electricity at maximum capacity (300 MW) for a whole year, it would be enough to power over 290,000 homes (~112,000 of those homes would be powered using the electricity generated from the steam turbine).

Fun Fact:

Water exists in three different forms (or states of matter): solid, liquid, and gas. To convert water from one form to another, all you have to do is change its temperature or pressure. FEP’s water system used to support the steam turbine uses the basic process outlined to the right:

1. Water is used to support the steam turbine process.
2. At FEP, water is heated and converted to steam using excess heat from the gas turbine. This process takes place in the heat recovery steam generator (HRSG).
3. Once the steam is used to power the steam turbine, it is condensed, cooled, and converted back into water.

### Parts of a Wind Turbine

**Blades:**
Most turbines have three blades. When turbine blades harness the wind, they lift and rotate, causing the rotor to spin.

**Rotor:**
The blades and hub together form the rotor.

**Nacelle:**
Sits atop the tower and contains the gear box, low and high speed shafts, generator, controller, and brake.

**Tower:**
Made from tubular steel, concrete, or steel lattice and serves as a structural base for the turbine. Because wind speed increases with height, taller towers allow turbines to capture more energy and generate more electricity.

### Generating Electricity from Wind

1. **Wind blows and turns the blades of the turbine.**
   When the sun heats the earth's surface it causes hot air to rise, reducing the earth's atmospheric pressure. Cooler air rushes in to replace the warm air and restore atmospheric pressure, resulting in wind.

2. **Turbine blades rotate to create energy.**
   When wind pushes against the blades of the turbine, the shaft inside the nacelle turns. The spinning of the turbine blades and shaft is energy in motion, or kinetic energy.

3. **A generator creates electricity.**
   The gear box inside the nacelle uses a large and small gear. The larger gear powers the smaller gear to turn at a faster pace, which rotates the generator to create electricity. This process converts mechanical energy into electrical energy.

4. **Electricity is sent over power lines and delivered to homes and businesses.**
   Power lines transfer electricity from where it is generated to the end user. Electricity produced by wind energy can be used in homes and businesses.

### Generating Electricity from the Sun

1. **The sun produces solar energy.**
   Heat and light from the sun produce solar energy.

2. **Solar panels convert solar energy into electricity.**
   Solar panels harness light from the sun and convert the solar energy into electrical energy.

3. **An inverter converts the electricity.**
   Most homes, schools, and businesses require alternating current (AC) electricity. An inverter is a device that converts the direct current (DC) electricity generated by the solar panels to AC electricity.

4. **Electricity is sent over power lines and delivered to homes and businesses.**
   Power lines transfer electricity from where it is generated to the end user. Electricity produced by solar energy can be used in homes and businesses.

### Wind & Solar Energy: Advantages and Disadvantages

Based on what you know, identify some advantages and disadvantages of wind & solar energy - specific to how it is used to generate electricity:

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fun Facts*</td>
<td></td>
</tr>
<tr>
<td>• Nearly 25% of Minnesota's electricity came from renewables in 2017</td>
<td></td>
</tr>
<tr>
<td>• Wind energy generated 18.2% of the state's electricity</td>
<td></td>
</tr>
<tr>
<td>• &quot;As a result of forward-looking state policies such as the Renewable Electricity Standard, along with technological advances and lower costs for renewables, Minnesota utilities are moving ahead with ambitious plans to expand their electricity generation from clean energy such as wind and solar.&quot;</td>
<td></td>
</tr>
</tbody>
</table>

Transferring Electricity from Power Plants To Homes

1. **Power Plant**
   Electricity is generated at power plants using non-renewable and renewable energy resources — natural gas, wind, solar, etc.

2. **Power Lines**
   Electricity travels from the power plant to your home through an interconnected network of electric power lines. The electricity can travel many miles via the transmission system. At the local level, electricity travels via the distribution system, which delivers the electricity to your home.

3. **Your Home**
   Electricity is wired directly into homes and businesses and used to power things such as lights, refrigerators, computers, and air-conditioning.

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**Activity**

We use electricity everyday. For many of us, it is something that is “just there” when we need it. Think of a time when electricity has not been available — such as a power outage. What are some things that could cause a power outage?

1. 
2. 
3. 

---

**Fun Fact**: The U.S. power system is comprised of “nearly 160,000 miles of high-voltage power lines, and millions of low-voltage power lines and distribution transformers, which connect 145 million customers.”

Take Home Activities

My Energy Usage

This section of the workbook is intended to help you build a better understanding of your home’s energy usage and learn ways to conserve energy at home. We encourage students to work with a parent or guardian to complete the information below:

Energy Usage

Where does your electricity come from (who is your electricity provider)?

____________________________________________________________________________________

How much electricity did your home use last month (should be included on your home’s electric bill)? ____________________________ (kWh)

Electricity Consumption, How I Use Electricity:

Explore your home and complete the information below.

• Number of electrical outlets: __________________

• Number of light switches: __________________

• Number of light bulbs: __________________

  Incandescent _______  CFL _______  LED _______

• Number of refrigerators: __________________

• Number of power strips: __________________

• Thermostat Temperature: _________________

General Observations: List some of the items that are currently using electricity in your home. Are there any items that you are not using that you could turn off or unplug?

____________________________________________________________________________________

Fun Fact: According to the U.S. Energy Information Administration, the average Minnesota household consumed 748 kWh per month* in 2017.

Home Energy Inventory

* U.S. Energy Information Administration [EIA], 2017 Average Monthly Bill- Residential, (Data from forms EIA-861-schedules 4A-D; EIA-861S and EIA-861U)
There are many things you can do every day at home to save energy. Using the Energy Conservation Checklist, see how you can save energy at home and find ways you may improve your energy conservation efforts.

Fill in the circle that best represents your current energy conservation efforts below.

1. How often are lights left on in rooms that aren’t being used?
   - [ ] Almost Always
   - [ ] Sometimes
   - [ ] Rarely

2. Count the number of LED/CFL bulbs being used in your home. How many are there?
   - [ ] None
   - [ ] 1–4
   - [ ] 5 or More

3. What type of thermostat do you have?
   - [ ] Non-Programmable
   - [ ] Programmable

4. What temperature is your thermostat set to in the winter?
   - [ ] 73 Degrees or Higher
   - [ ] 69–72 Degrees
   - [ ] 68 or Lower

5. What temperature is your thermostat set to in the summer?
   - [ ] 73 Degrees or Lower
   - [ ] 74–77 Degrees
   - [ ] 78 or Higher

6. How often is the TV left on when no one is watching it?
   - [ ] Almost Always
   - [ ] Sometimes
   - [ ] Rarely

7. How often is the computer left on when no one is using it?
   - [ ] Almost Always
   - [ ] Sometimes
   - [ ] Rarely

8. Count the number of chargers plugged in and not being used. How many are there?
   - [ ] 1 or More
   - [ ] 1-2
   - [ ] None

9. How often is the bathroom water left running when it isn’t being used?
   - [ ] Almost Always
   - [ ] Sometimes
   - [ ] Rarely

Total the number in each of the circles you filled in.

If your total was 9–14 Points, you are an ENERGY USER
You’re almost there! While you might save energy in certain ways around your house, try to think of more ways you can conserve. Is there anything on the checklist that you can focus on and improve?

If your total was 15–27 Points, you are an ENERGY SAVER
Great job saving energy! You do a very good job of conserving energy and being environmentally friendly. Continue to make energy saving decisions in your everyday activities at home.

MMPA encourages you to conserve energy at home.
Many of us use electricity to provide our homes with light, hot water, heat, and air-conditioning. Electricity is essential, but it’s important to use only as much as we need. By conserving energy, you can help keep costs down for your home and reduce the overall demand for electricity on our system. Conservation also helps MMPA control the need for new electric generation and helps the environment by reducing emissions from power production.

Energy conservation is any behavior that results in the use of less energy.

Energy Conservation Tips

Unplug It
- Unplug appliances such as computers and monitors, coffee makers, toasters, etc., when not in use.
- Unplug devices and chargers once your device battery is fully charged (cell phones, digital cameras, handheld video games and devices).

Turn it Off
- Plug televisions, entertainment center equipment, and other appliances into power strips and switch them off when not in use.
- Turn off fans and lighting in unoccupied rooms.

Turn it On
- When it is time to replace your incandescent light bulbs, switch to energy-saving light-emitting diode bulbs (LEDs) or compact fluorescent bulbs (CFLs).
- Set the air conditioner thermostat to 78 degrees or higher.
- Set your computer to energy saving power save/sleep mode.

Cool it Down
- Grill meals outside during the summer to keep your home cool.
- Operate your oven, dishwasher, washing machine and dryer during the cooler part of the day, since running these appliances raises the temperature inside your home.
- Use ceiling and floor fans to help circulate air and make the room you are in feel cooler. In fact, use of a ceiling fan in the summer can allow you to raise your thermostat four degrees without affecting your comfort level.
- Close blinds and curtains on west- and south-facing windows during the day.

Clean it Up
- Clean the lint filter in the dryer after each load of laundry to improve air circulation.
- Clean or replace central air conditioner filters monthly for peak efficiency.
## Energy Education Word Find

**Directions:** Circle the terms from the word bank in the word find below. Words appear horizontally, vertically, and diagonally.

### WORD BANK

<table>
<thead>
<tr>
<th>BIOMASS</th>
<th>ELECTRICITY</th>
<th>MEGAWATT</th>
<th>POWER LINES</th>
</tr>
</thead>
<tbody>
<tr>
<td>COAL</td>
<td>ENERGY</td>
<td>MINNESOTA</td>
<td>POWER PLANT</td>
</tr>
<tr>
<td>COMBINED CYCLE</td>
<td>GENERATOR</td>
<td>MMPA</td>
<td>RENEWABLE</td>
</tr>
<tr>
<td>CONSERVATION</td>
<td>GEOTHERMAL</td>
<td>MUNICIPAL</td>
<td>SOLAR</td>
</tr>
<tr>
<td>DISTRIBUTION</td>
<td>HOMEOWN</td>
<td>NATURAL GAS</td>
<td>SOLAR PANELS</td>
</tr>
<tr>
<td>EDUCATION</td>
<td>HYDRO</td>
<td>NONRENEWABLE</td>
<td>TRANSMISSION</td>
</tr>
<tr>
<td>ELECTRIC UTILITY</td>
<td>KILOWATT</td>
<td>NUCLEAR</td>
<td>WIND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>POWER</td>
<td>WIND TURBINE</td>
</tr>
</tbody>
</table>

In preparation for your Energy Education Event, please prepare a list of questions and/or comments. Think about questions you may have specific to MMPA, electricity, energy sources, power generation, energy conservation, etc.