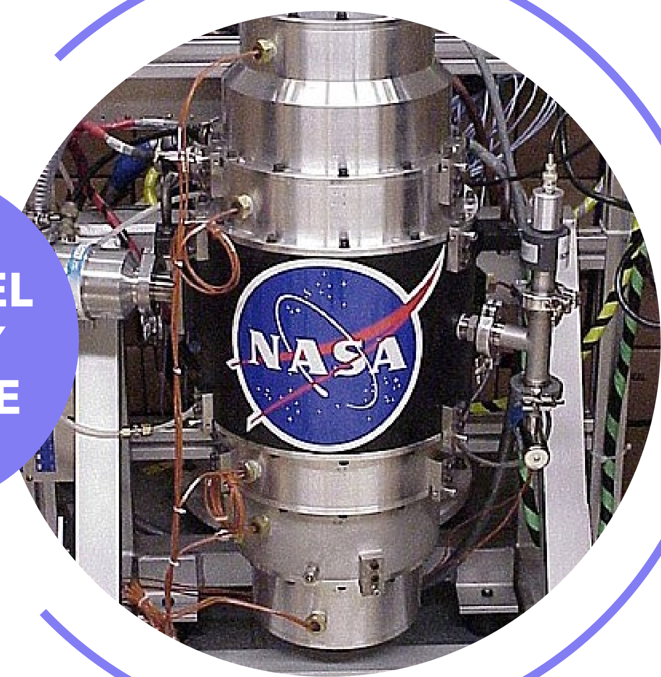
ENERGY INNOVATION CARD

FLYWHEEL ENERGY STORAGE



Sit on the map and read the following with your group.

Flywheel energy storage is a type of technology that works by storing energy in a rotating disk. This disk is powered by a generator. Electricity enters the generator, the wheel accelerates, and the energy is stored as momentum on the wheel. When we need energy, the momentum of the spinning wheel drives the generator, which generates electricity, and the wheel slows down. The energy stored can then be used to power the generator whenever additional energy is needed or there is a power outage from the grid. Companies like Google have flywheel storage systems at their facilities to store excess energy for times of need.

How does flywheel storage technology compare to standard battery storage? Flywheel storage has a long lifespan, requires little maintenance, and does not contain any hazardous materials. This type of energy storage has a fast response time and can supply a lot of power in a relatively short amount of time. However, the efficiency, durability, and power density (i.e., the amount of power produced relative to the volume of the energy system) is dependent on the quality and strength of materials used to manufacture the flywheel energy storage system. For example, friction in the bearings of the rotor can cause energy loss, produce heat, and lead to mechanical failure (i.e., the flywheel could break apart).

New prototypes of flywheel energy storage systems continue to be developed in order to maximize efficiency, extend the amount of time that the disks can spin, and increase the amount of storage capacity. There are some limitations on flywheel energy storage that have slowed the uptake of this technology, such as the fact that these systems are not portable like batteries. However, flywheel technology does not pollute the environment, whereas lithium-ion batteries result in toxic waste at the end of their lifecycle, produce toxic and radioactive materials that must be stored for anywhere from a few months to a few thousand years until the radioactivity of the waste has dropped to safe levels.

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Discuss the following in your group.

1. If you were asked to design and build a flywheel energy storage system to provide power and energy storage to off-grid communities, where in Canada would you install it, and why?

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MICRO-HYDROPOWER SYSTEMS

Sit on the map and read the following with your group.

Hydropower is a renewable energy source that gets electricity from the kinetic energy of flowing water. You might have seen images of large hydroelectric dams in Canada, particularly in Quebec. Micro-hydropower systems are hydropower dams on a smaller scale, generating less than 100kW. They don't usually have much impact on the local ecosystem as they do not involve large dams or water reservoirs.

These small-scale hydropower facilities are also sometimes referred to as "run-of-the-river" systems. A run-of-the-river facility would take in water directly from the source (a stream or river), and then a pipeline would bring the water to a turbine (where debris would be filtered out from the water before it enters the turbine), which would convert the energy of falling water into electricity. A channel then brings the water back to the water source, and, finally, transmission lines bring electricity to its destination.

These types of systems have the potential to be installed on streams and rivers across Canada, even on people's private property, to help provide clean electricity to local homes and businesses. With proper maintenance, these systems could last 20 to 30 years. The energy potential of rivers and streams depends on their flow rate (i.e., how much water flows per second), the height from which the water is falling, and the force of gravity.

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Discuss the following in your group.

1. If you were asked to design and build a micro-hydropower system to provide power and energy storage to off-grid communities, where in Canada would you build it, and why?

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CONCENTRATED SOLAR THERMAL ENERGY

Sit on the map and read the following with your group.

Concentrated solar thermal energy, or concentrating/concentration solar power (CSP) could be a great addition to solar energy in Canada. Solar energy is a renewable source of energy, but it only works during the day. What if there was a way to concentrate that solar energy and store it? This is where CSP really “shines.” For solar energy to be a reliable energy choice, it needs to be available on demand, meaning that people can access electricity from it at any time.

The solar panels you are probably used to seeing are photovoltaic. These solar cells get their name from the photovoltaic process in which sunlight (i.e., photons of solar energy) is absorbed by semiconductor materials in the solar cell to produce an electric current (i.e., voltage). How does CSP compare with solar photovoltaic technology? Imagine using a magnifying glass or a mirror to concentrate the sun on one spot. That spot gets extremely hot! This is how CSP works. While CSP technology is more efficient and can store energy, it is more expensive than photovoltaic technology, which is why photovoltaic is currently the more popular option in Canada.

CSP uses mirrors that track and move with the sun to reflect sunlight and focus that light on one specific area called a receiver. There are many types of CSP technologies: towers, dishes, linear mirrors, and troughs. For example, parabolic troughs are large, U-shaped mirrors that are connected together to form a system. The curved shape of the trough allows most of the sun’s heat to be reflected onto a receiver tube, which is filled with a fluid that retains heat, such as oil or molten salt. Next, this hot fluid turns water into steam in something called a heat exchanger. The steam then travels to a steam turbine, which spins a generator to generate electricity. What is fascinating about this technology is that once the fluid has transferred its heat, it can be reused and the heated fluid can even be stored to be used later (e.g., at night). This means electricity can be accessed even when the sun is not shining!

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Discuss the following in your group.

1. If you were asked to design and build a concentrated solar thermal plant to provide power and energy storage to off-grid communities, where in Canada would you build it, and why?

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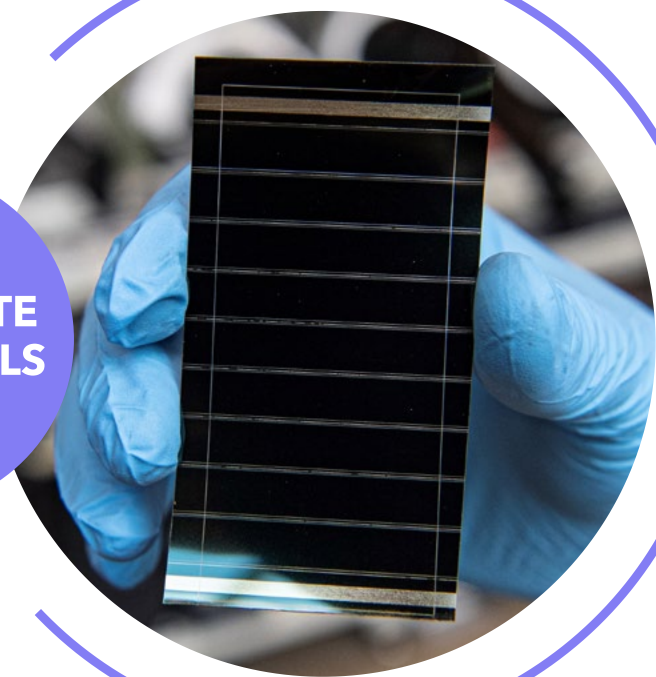

PEROVSKITE SOLAR CELLS

Sit on the map and read the following with your group.

Perovskite solar cells are different from photovoltaic cells in several ways. Conventional photovoltaic solar cells use high-grade silicon which is extracted from the earth and processed to manufacture the solar cells. These solar cells get their name from the photovoltaic process in which sunlight (i.e., photons of solar energy) is absorbed by semiconductor materials in the solar cell to produce an electric current (i.e., voltage). The manufacture of photovoltaic cells creates chemicals that don't break down easily or quickly in the environment, such as perfluorocarbons (PFCs). Other toxic chemicals include lead and cadmium. In addition, large amounts of water and energy are needed to refine the raw materials and make the photovoltaic solar cell.

Perovskite solar cells are made up of materials called "perovskites," which are created through "solution processing" (i.e., materials are deposited from a solution onto a surface). This process yields entirely human-made materials with a crystal structure (which is compared to the compound calcium titanium oxide). Unlike photovoltaic cells, which require silicone to be mined and processed, perovskite cells are made in a lab. This means that the scale of manufacturing for this artificial material can be as big or small as needed to suit production costs. In addition, perovskite solar cells take the form of thin-film, flexible panels that are more energy efficient than photovoltaic cells. Perovskite solar cells are a promising renewable energy technology because they are potentially cheaper to manufacture, lightweight, more efficient, and the production process is more flexible.

This type of solar energy technology is still being developed and fine-tuned through research. Scientists are looking into how they can combine different chemicals to create more varieties of crystal compositions of perovskite and how these materials could be tuned for different wavelengths of light. There are also certain challenges to overcome with this technology. For example, there are issues that need to be addressed concerning the toxicity of some of the cell components and perovskite byproducts. Also, the lifespan of perovskite solar cells is very short and not commercially viable for most purposes. There is great potential in perovskite solar cells, but a lot of research and development still needs to happen in order to maximize the efficiency of power production to compete with photovoltaic cells.

Discuss the following in your group.

1. If you were asked to design and build a perovskite solar cell system to provide power and energy storage to off-grid communities, where in Canada would you build it, and why?

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TIDAL ENERGY

Sit on the map and read the following with your group.

There is immense potential for tidal energy in Canada. By one estimate, Canada has enough tidal energy potential to displace more than 113 million tonnes of carbon dioxide, which is like taking 24 million cars off the road. The Minas Passage area in the Bay of Fundy has enough energy potential to power all of Atlantic Canada – that's a lot of energy!

The gravitational pull of the moon as well as the sun and the rotation of the Earth, are what create tides. These factors are predictable, which means that the energy we can get from tides is predictable too (as opposed to wind or solar). You will often find tidal resources where the water is "pinched" – where coastlines get closer to one another (think of the St. Lawrence River narrowing near Québec City) – or where the seafloor shallows. This "pinching" makes the water go faster, which increases its power. Think of it like pinching a garden hose – when you press your thumb on it, the speed at which it flows out increases. The difference between high tide and low tide needs to be at least five metres to create electricity.

Tidal range technology (tidal barrage, tidal dam) functions like a hydroelectric dam. As the tide comes in (high tide), a tidal barrage holds the water, and then the tide flows out (low tide). There is now a height difference between the held water and the low tide. This height difference creates potential energy. The held water can be emptied through a turbine and converted to electrical energy.

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Tidal stream technology works similarly to a wind turbine underwater. A turbine is placed in tidal currents and electricity is produced by the kinetic energy from the natural flow of the moving water. This technology has a smaller effect on water flow and sedimentation than tidal range technology, can be installed in steps (so as to monitor the effect on the environment) and has little environmental impact. Tidal range technologies have more environmental impacts and risks than tidal stream technology, but they are more efficient.

While there is a great potential in tidal energy, the cycles of tides don't always align with our energy usage patterns, meaning that when the tides are producing energy might not be when we need it. There are also unique requirements for where tidal energy facilities can be installed, which means it has been slow to enter the energy mix worldwide.

Discuss the following in your group.

1. If you were asked to design and build a tidal barrage to provide power and energy storage to off-grid communities, where in Canada would you build it, and why?

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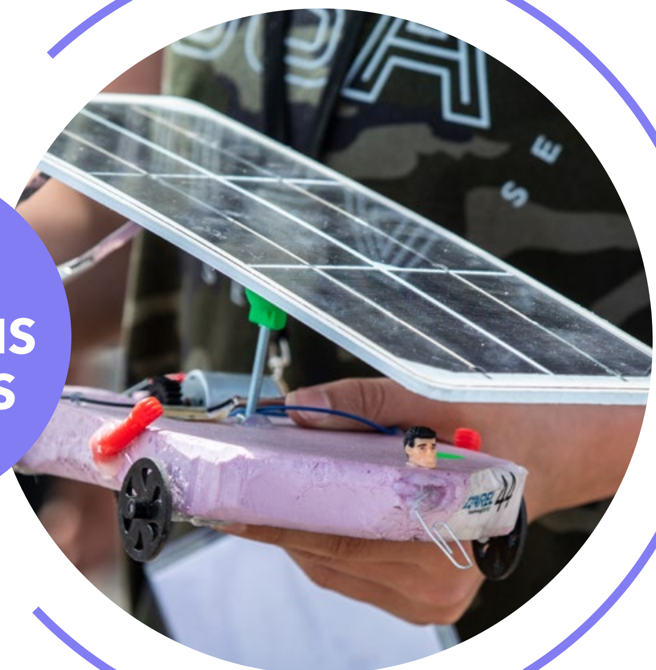
ZERO-EMISSIONS VEHICLES



Sit on the map and read the following with your group.

Transportation contributes to nearly a quarter of Canada's greenhouse gas emissions, and about half of those emissions comes from passenger vehicles (e.g., cars and pickup trucks). An important aspect of reaching Canada's net zero emissions by 2050 is to increase the amount of zero-emission vehicles (ZEVs) on Canadian roads. A ZEV is a vehicle that can operate with no tailpipe emissions. It can still have a traditional internal combustion engine but must be able to run without it. There are a few types of zero-emission vehicles: battery-electric, plug-in hybrid electric, and hydrogen fuel cell.

Canada's current government has committed that all cars and light-duty trucks sold in Canada must be ZEVs by 2035. This is an ambitious goal and Canada needs to ramp up its research and development into zero-emission vehicles and the infrastructure needed to support these vehicles in all communities across Canada.

For it to be feasible for all new light-duty vehicles to be ZEVs, there need to be charging and refuelling stations across Canada, including in areas traditionally underserved by this type of service. With this in mind, the government has committed to supporting the installation of 33,500 EV chargers and 10 hydrogen-refuelling stations across Canada.

While ZEVs do not emit carbon, are zero-emission vehicles "greener" than other vehicles? This question is one open for debate, with many variables to consider. What source of energy is being used to charge the car (renewable or non-renewable)? What materials are being used to create the battery in the car? Lithium-ion batteries (used in most electric vehicles) use raw materials that pose environmental concerns. Manufacturers are investigating ways to do away with certain materials in the battery production process, but this technology is not yet ready. Also, only about five per cent of lithium-ion batteries are recycled; however, people are finding innovative ways to give the batteries a second life, such as in grid energy storage.

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Discuss the following in your group.

1. If you were asked to design and build a system of electric charging stations to provide power for transportation purposes, where in Canada would you build it, and why?

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SMALL MODULAR REACTOR

Sit on the map and read the following with your group.

Small Modular Reactors (SMRs) are a new nuclear technology that allows for the production of a large amount of energy at a fraction of the size of a standard nuclear energy facility. This emerging technology does not produce greenhouse gas emissions and can fill the gap found in remote and rural areas where diesel power generation is being used. These modular nuclear reactors can be used to power communities across Canada and provide a reliable and clean energy source that is much needed.

SMRs can be built in these remote regions because of the reduced industrial requirements of the facilities. The small size of SMRs does not require as large a development process, workforce, or resources as conventional nuclear power facilities. The components of a modular reactor can be manufactured and then sent to their intended location to be assembled and installed. Also, SMR designs are often simpler, safer, and require less fuel (i.e., uranium) than large nuclear reactors.

Other than power generation, SMRs have the potential to assist in a number of different applications, such as district heating systems, desalinated drinking water, and the production of hydrogen fuel.

In the event of the manufacturing of SMRs in Canada they will need to have specific designation under the Canadian Nuclear Safety Commission's regulatory framework. This is the framework that governs how all nuclear facilities in Canada are managed, and there would need to be a new guideline put in place. The locations and the amount of energy produced will vary greatly compared to the existing criteria for nuclear facilities.

Although nuclear technology is very efficient and capable of producing large amounts of energy without emitting greenhouse gases, there are environmental factors to take into account. SMRs, like traditional nuclear facilities, produce toxic and radioactive materials that must be stored for anywhere from a few months to a few thousand years until the radioactivity of the waste has dropped to safe levels. SMRs also require a lot of energy and resources to be manufactured, transported to their location, and installed. There is still much research that needs to be undertaken into the safety measures and environmental impacts of SMRs.

Discuss the following in your group.

1. If you were asked to design and build a small modular reactor to provide power and energy storage to off-grid communities, where in Canada would you build it, and why?