ENERGY INNOVATIONS

TEACHER'S GUIDE

Inside education

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Edmonton Office
11428 - 100 Avenue
Edmonton, AB T5K 0J4
780-421-1497

Calgary Office
410-622 5th Ave SW
Calgary, AB T2P 0m6
403-263-7720

info@insideeducation.ca

www.InsideEducation.ca

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#101894319RR0001

@insideeducation facebook.com/insideeducation @insideeducation

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INTRODUCTION

Welcome to Inside Education's Energy Innovation Poster! This poster and teacher's guide are filled with information and activities that can fit a variety of grade levels and classrooms. Use this resource and have fun exploring energy innovations with your students!

LAND ACKNOWLEDGEMENT

Energy comes from natural resources and it is important to acknowledge that the land our energy resources come from has been home to indigenous people for thousands of years. Inside Education's work brings us to all corners of the province, as such, we acknowledge the Indigenous Peoples who lived among and travelled through the land in the area currently known as Alberta. The relationship the Peoples of Treaty 6, Treaty 7, and Treaty 8 and Alberta's Métis Peoples have with the land is founded on a deep respect for the environment. This connection forms the foundation of our personal responsibility for the stewardship of our natural resources, a connection Inside Education strives to foster among students and teachers through our diverse programming, which includes this Energy Innovation Poster.

WHY AN EDUCATIONAL RESOURCE ON ENERGY INNOVATIONS?

Energy is an integral part of our modern lives - we all use energy in its various forms daily, so it's important to know where it comes from, how it's generated, and how energy development and use influences our economy, environment and society. It's important to give students the foundation to think critically and engage in conversations about energy topics in a balanced way that incorporates many perspectives.

POSTER OVERVIEW

Showcasing science, technology, stewardship, innovation, and careers relating to electricity, this poster can enhance lessons and provide students with creative critical thinking opportunities.

ENERGY CONNECTIONS - ALBERTA CURRICULUM

The Energy Innovation Poster was developed with Grades 7-12 students in mind but can be adapted to fit with a variety of science, social studies and environmental education topics that explore energy and natural resources.

- Grade 5 Science - Energy Resources (renewable vs non-renewable)
- Grade 6 Science - Energy Resources (selecting energy resources, pre vs post processing, uses of energy)
- Grade 7 Science Unit A: Interactions and Ecosystems, Unit C: Heat and Temperature
- Grade 8 Science Unit D: Mechanical Systems
- Grade 9 Science Unit C: Environmental Chemistry
- Grade 9 Science Unit D: Electrical Principles and Technologies
- Career & Technology Studies Cluster D: Natural Resources (NAT)

POSTER OVERVIEW

Showcasing science, technology, stewardship, innovation and careers related to energy, this poster is designed to elevate energy education in the classroom and provide students with critical thinking opportunities.

GUIDING QUESTIONS

- Where does energy come from?
- Why is the energy landscape changing?
- How is the energy landscape changing through technology and innovations?
- How can students be involved in Alberta's energy future?
- How is the energy landscape connected to Science, Technology & Society (STS)?

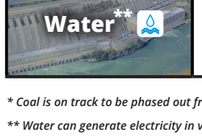
MAJOR THEMES

- Climate Change & Greenhouse Gas Emissions
- Renewable & Alternative Energy
- Fossil Fuel Innovations
- Clean Fuels

ENERGY & NATURAL RESOURCES BACKGROUNDER

Natural resources used to produce energy in Alberta and Canada are found in the air, in the water, above ground, and underground. Many factors are considered before these raw natural resources are changed into energy, whether it is energy used for electricity, heating, transportation or manufacturing. Access to the natural resource, cost to build infrastructure (e.g. power plants, transmission lines etc.), the financial market, demand for energy, and environmental factors are only some of the considerations.

The following chart describes some common opportunities and challenges faced by industries, governments and even consumers when deciding which resource to use to produce energy.

NATURAL RESOURCE	OPPORTUNITIES	CHALLENGES
 Natural Gas	• We have lots in Alberta • Sell to other countries to grow our economy • Natural gas power plants respond easily to changes in energy demand	• Non-renewable • Greenhouse gas emissions • Pipelines and wells have an impact on land, air, water, plants and animals
 Oil	• We have lots in the Alberta • Source of electricity in remote communities • Sell to other countries to grow our economy	• Non-renewable • Greenhouse gas emissions • Seismic lines, wells, pipelines, rail lines have an impact on land, air, water, plants and animals • Water is used during extraction, production and refining
 Coal *	• We have lots in Alberta • Lower costs compared to other resources because mines, power plants and transmission lines already exist	• Non-renewable • Greenhouse gas emissions • Mines have an impact on land, air, water, plants and animals • Coal-fired power plants respond slowly to changes in electricity demand
 Nuclear	• A small amount of uranium makes a lot of energy (efficient) • No greenhouse gases are emitted	• Non-renewable • Radioactive waste is produced • High cost to build a power plant • Uranium is mined in remote locations and transported long distances to power plants
 Geothermal	• Renewable • No greenhouse gases are emitted • Reliable source of energy *(supply doesn't change)*	• High cost to build wells and power plants • Not available everywhere *(parts of Alberta have low underground temperatures)*
 Solar	• Renewable • No greenhouse gases are emitted • Photovoltaic *(solar)* panels require little maintenance once built • Solar panels can be built where you need them *(i.e. on the roof of a home)*	• High cost to build solar panels • Supply varies throughout the day and is not available at night • Energy storage technology is lacking for large projects
 Biomass	• Renewable • Makes use of waste material that would otherwise contribute to landfills *(wood chips, cow manure, food waste, etc.)*	• Greenhouse gases produced • Limited supply of waste material in some cases. • If grown for just energy this impacts land for food production
 Wind	• Renewable • No greenhouse gases are emitted • Small physical footprint on the landscape	• Supply varies and wind speeds can be too high or too low • Wind turbines obstruct views • Birds and bats flight paths affected
 Water **	• Renewable • No greenhouse gases are emitted • Reservoir can be used for recreation • Responds quickly to changes in electricity demand	• High up front cost to build dams and reservoirs • Impacts river/stream flow and aquatic habitat • Reservoirs flood surrounding land impacting local communities, including First Nations

**** Coal is on track to be phased out from heat and energy production in Alberta in early 2024***

***** Water can generate electricity in various forms (eg. run of the river, tidal and hydro). In Alberta, water is only used in hydro generation***

ENERGY EYE SPY (JR/SR HIGH)

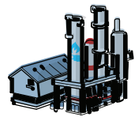
This activity is designed to familiarize your students with some of the terms on the Energy Innovation Poster. Divide the class into small groups and provide each group with a copy of the poster (digital or hard copy). Read the questions one by one and have students share what they find.

Questions:

* Where does most of Alberta's **electricity** currently come from?
* How many **elements and compounds** can you find?
* How many examples of **renewable energy** can you find? (hint: look for the yellow outlines!)
* How many **energy storage** facilities can you find? (hint: look for the yellow outlines!)
* How many **environmental monitoring** stations can you find?
* Where is **carbon dioxide** being used in innovative ways?
* What does **SAG-D** stand for?
* What does **SAF** stand for?
* What could be powering the **train**?
* What is powering the **buses**?
* Find the **electric vehicle charging station**
* In what ways is **Hydrogen** being used on the poster?
* Where is **organic material** (i.e. wood chips, crop waste, etc.) being used? (hint: look for the orange outlines!)
* What **careers** are shown?
* Where do **you** fit in?
    - Are there any innovations depicted on the poster that you have seen in your own community?
    - Which innovations do you know most about?
    - Which innovations have you never heard of?

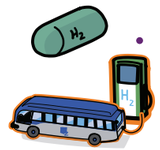
ENERGY EYE SPY (JR/SR HIGH) - ANSWER KEY

* Where does most of Alberta's **electricity** currently come from?



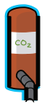
- **Natural gas plant** - look for CH_4! - In 2023, natural gas made up 69% of Alberta's electricity generation ("AESO 2023 Annual Market Statistics").
- Natural gas production is becoming increasingly efficient through combined-cycle technology, which involves capturing heat that would otherwise go to waste to turn an additional turbine and generate even more electricity.
- Coal is on track to be phased out from electricity generation in Alberta in early 2024.

* How many **elements and compounds** can you find?

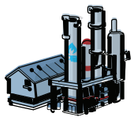


- **H_2 (Hydrogen)** - ***on fuel tank, bus and fuelling station*** - Hydrogen can be blended with natural gas to make heating buildings more efficient, and used as a transportation fuel.

- **Li (Lithium) - *lithium mine*** - Lithium can be mined for Lithium-ion batteries, which are increasingly in demand as more Electrical Vehicles emerge onto the market and as a form of energy storage to accompany renewable energy (i.e. wind, solar) technologies.



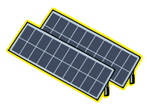
- **CO_2 (Carbon dioxide)** - carbon capture pipeline and carbon storage facility - Carbon dioxide can be captured and stored underground or converted into products.



- **CH_4 (Methane)** - ***renewable natural gas storage tank, natural gas facility*** - Natural gas is mostly made up of methane and is used for heating, electricity and transportation in Alberta. Natural gas is also being produced from renewable resources, which is called Renewable Natural Gas.

* How many examples of **renewable energy** can you find? (*hint: look for the yellow outlines!*)

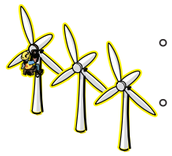
- **Solar panels (on solar farm and building roofs)**



    - In 2023, solar energy made up 2.7% of Alberta's electricity generation ("AESO 2023 Annual Market Statistics").
    - Solar is renewable (we have an unlimited supply of it), and once the panels are built, no greenhouse gases are released.
    - An increasing number of companies and individuals are investing in solar arrays. Solar energy technology is greatly advancing and becoming more efficient.
    - Monofacial panels, typically installed on rooftops, have only one working side that faces the sun, with the other side facing the roof of the building, away from direct sunlight. In contrast, bifacial modules can receive sunlight on both sides to generate even more electricity from ground reflection.
    - When the solar panels are installed, the location and angle of the panels must be considered to receive the maximum amount of sunlight possible.
    - Alberta has the 2nd highest solar potential of all Canadian provinces/territories (behind Saskatchewan), meaning it's very sunny here.
    - A challenge with solar is intermittency, meaning it's not always sunny (*see "energy storage" topics to learn more about what's being done to combat this intermittency challenge*).

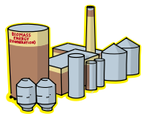
ENERGY EYE SPY (JR/SR HIGH) - ANSWER KEY

- **Wind farm**



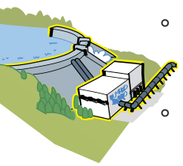
  - Wind is the highest producing renewable resource on Alberta's electricity grid. In 2023, wind provided 22% of Alberta's electricity ("AESO 2023 Annual Market Statistics"), and that percentage is rising as more and more turbines are built.
  - Wind is renewable (meaning we won't run out of it), and once the infrastructure is built, no greenhouse gasses are released from generation.
  - The technology behind wind turbines is constantly evolving - for example, some wind turbines have blades that automatically adjust to respond to changes in wind direction, and research into ultrasonic sound devices to deter bats and birds is underway.
  - Similar to solar, a challenge with wind is intermittency (i.e. it's not always windy), but energy storage can help combat this challenge.

- **Biomass**



  - Biomass is any organic material (i.e. wood chips, food waste, crop residue, etc.) that can be burned or gasified to generate electricity.
  - For example, farms can use their crop waste, lumber mills can use their wood chips, and wastewater plants can use their solids to generate power.
  - This process is not only using up materials that would otherwise go to waste, but it's also a way for these facilities to make some extra money because they can sell the electricity back to the grid.
  - A challenge however is that although biomass uses renewable resources, the burning or gasifying process does release greenhouse gases into the atmosphere.

- **Hydroelectric dam**



  - Although hydro is 60% of Canada's overall electricity supply ("Canada Energy Regulator Fact Sheet"), only 2% of Alberta's electricity comes from hydro ("AESO 2023 Annual Market Statistics"), which is from just a few hydroelectric dams, mostly located in the Bow Valley.
  - Hydro is considered a renewable resource (although this gets tricky as there start to be more and more drought periods), and once the dam is built there are no greenhouse gas emissions released.
  - However, building a hydro dam has impacts on the plants, animals and people that live up and downstream.

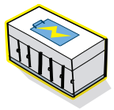
- **Geothermal well**

  - Geothermal energy has been used for heat in some houses and buildings in Alberta for a long time, but is just starting to be used for electricity in Alberta.
  - Look up Swan Hills Geothermal to learn more about a newly operational geothermal and natural gas co-production facility.
  - In addition to being a clean & renewable form of electricity generation, geothermal can also help combat Alberta's orphaned well situation by utilizing decommissioned oil and gas wells to access geothermal heat.

ENERGY EYE SPY (JR/SR HIGH) - ANSWER KEY

* How many **energy storage** facilities can you find? (*hint: look for the yellow outlines!*)

- **Lithium ion batteries**



  - One of the challenges with renewable energy is the intermittent supply (i.e. the sun isn't always shining and the wind isn't always blowing).
  - For this reason, there is a lot of work going towards finding ways to store electricity from these sources so it can be used during down-times.
  - One example in Alberta of a storage facility is WindCharger: WindCharger is Alberta's first utility-scale, lithium-ion energy storage project and utilizes Tesla Megapack technology.

- **Pumped hydro**

  - Water is pumped up to a reservoir and held. When energy is needed, the water in the reservoir is released and flows downhill (due to gravity), so it can turn a turbine and generate energy.
  - The water is then pumped back up to the reservoir and the whole process starts all over again.
  - TC Energy is currently building a pumped hydro project (called Canyon Creek) near Hinton, at the site of a decommissioned coal mine.

- Other energy storage technologies (not on poster) include flywheels, compressed air and hydrogen.

* How many **environmental monitoring** stations can you find? (*hint: look for the yellow outlines!*)

- **Water monitoring station** - This water monitoring station could be testing pH, flow rate, sediment composition, chemicals (nitrates/nitrites/phosphates), temperature, etc. to determine if the upstream activities are having an impact on water quality and quantity.

- **Soil monitoring station** - This soil monitoring station could be measuring pH, temperature, texture (silt/sand/clay), chemicals, etc. to determine if the surrounding activities and changing climate are having an impact on soil quality.

- **Air quality monitoring station** - This air quality monitoring station could be measuring particulate matter (PM2.5 and PM10), carbon dioxide, carbon monoxide, nitrous oxides, sulphur dioxide, temperature, etc. to measure and track air quality throughout the year.

- **Snowpack monitoring station** - This snowpack monitoring station could be measuring snow depth, temperature, ice pack, etc. to determine if and how the snowpack is changing over time.

- **Hydrogen Sulphide (H_2S) monitor** - Hydrogen Sulphide monitors are important for safety because they alert workers if Hydrogen Sulphide levels are above a threshold.

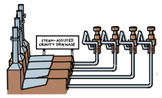
- **Landfill monitor** - Landfill monitors sample and landfill gas for its methane, carbon dioxide, nitrogen and oxygen concentrations.

ENERGY EYE SPY (JR/SR HIGH) - ANSWER KEY

✱ Where is **carbon dioxide** being used in innovative ways?

- **Carbon capture pipeline** - Carbon dioxide is captured from emissions from oil and gas production and transported to a carbon storage facility.
- **Carbon storage facility** - Carbon dioxide is stored in geological formations underground.

- **Carbon Technologies building** - Carbon can be utilised - for example, it can be made into products such as soap, concrete and carbon fibre products like hockey sticks.



✱ What does **SAG-D** stand for?

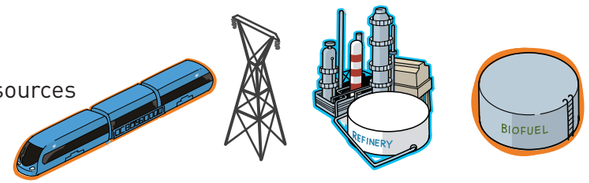
- **Steam Assisted Gravity Drainage** - In SAG-D, two horizontal wells are drilled about five metres apart, one over top of the other. Steam is injected into the top well, which heats the bitumen until it's mobile enough to flow to the lower well. SAG-D has less physical impact than oil sands mining.

✱ What does **SAF** stand for?

- **Sustainable Aviation Fuels** - In SAG-D, two horizontal wells are drilled about five metres apart, one over top of the other. Steam is injected into the top well, which heats the bitumen until it's mobile enough to flow to the lower well. SAG-D has less physical impact than oil sands mining.

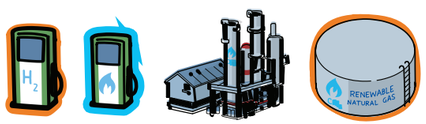
✱ What could be powering the **train**?

- Electricity - from renewable or non-renewable resources
- Hydrogen
- Clean fuels

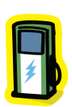


✱ What is powering the **bus**?

- Hydrogen
- 'Clean air vehicle' - natural gas



✱ Find the **electric vehicle charging station**



- Electrical Vehicles (EVs) are on the rise and the Canadian government has committed to 100% zero-emission vehicle sales by 2035 for all new light-duty vehicles ("Canada's Zero-Emission vehicle sales targets")
- EV-only manufacturing regulation set by federal government

ENERGY EYE SPY (JR/SR HIGH) - ANSWER KEY

✱ In what ways is **hydrogen** being used on the poster?

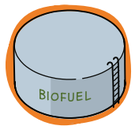
- Heating - hydrogen blended into natural gas for heating
- Bus - hydrogen fuel for transportation
- Hydrogen can also be used for electricity

✱ Where is organic material (i.e. wood chips, crop waste, etc.) being used? (hint: look for the orange outlines!)

- **Renewable Natural Gas storage tank**

  - When organic materials decompose, methane is released - we call this methane biogas. The methane can be captured and turned into renewable natural gas.
  - Renewable Natural Gas is biogas that has been processed to remove impurities so it can be used the same way we use natural gas from fossil fuels.
  - It is considered carbon neutral because it is capturing methane that would otherwise be released to the atmosphere.

- **Biofuel storage tank**

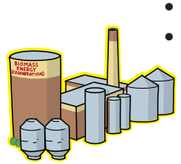


  - A biofuel is a liquid fuel that is produced from a renewable resource.
  - Biofuels can be produced from a variety of sources including wood chips, plants, animal fats, food waste, crop residues or even algae!
  - A biorefinery is where biomass is turned into biofuels.
  - Types of biofuels include Ethanol, Biodiesel, Methanol and Butanol.
  - Biofuels can help reduce our reliance on fossil fuels, which is especially important in the transportation sector where we burn gasoline, diesel and jet fuel.
  - Plants, like corn, can be fermented into ethanol and methanol. We add ethanol to existing fuels to reduce the amount of fossil fuels needed. The next time you are at a gas station, look for the 'ethanol content' in the gasoline!
  - Biofuels can also be created from used cooking oil and grease - creating a synthetic biodiesel that can be blended with regular diesel to reduce emissions.
  - Biofuels are being used to make biodiesel and as a blend with other fuels. (i.e. Sustainable Aviation Fuels).

- **Sustainable Aviation Fuels truck**

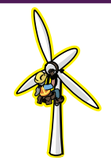
  - Sustainable Aviation Fuels are made from residual raw materials like cooking oil, and they have 80% less greenhouse gas emissions compared to fossil fuel based jet fuels. ("Sustainable Aviation Fuel | Decarbonisation")

- **Biomass energy (cogeneration) at pulp mill**



  - Wood chips are burned to generate electricity that can be sold back to the electricity grid.
  - This burning process releases greenhouse gas emissions, however it is using a product (wood chips) that would otherwise go to waste.

ENERGY EYE SPY (JR/SR HIGH)



* What **careers** are shown?

- Wind turbine technician (climbing wind turbine)
- Reclamation assessor/biologist (with H_2S monitor)

- Environmental scientist (checking snowpack monitor)

- Soil scientist (doing soil auger)

- Electrician (working on transmission lines)
- Careers not explicitly shown - solar panel researcher, pumped hydro operator, geothermal well technician, safety expert...
- Discuss:
  - ° Many people in Canada and around the world work with energy both directly and indirectly. Using the poster, find some jobs that people have that involve energy.
  - ° Would you be interested in any of these careers?
  - ° How have these careers changed in the last 30 years?
  - ° Do you believe these careers will change in 30 years? What predictions can you make about how they may change and why?

* Where do **you** fit in?

- Are there any innovations depicted on the poster have that you seen in your own community?
- Which innovations do you know most about?
- Which innovations have you never heard of?
- Which innovations are you curious to learn more about?

CONNECTIONS: PLUGGING INTO THE ENERGY LANDSCAPE (JR/SR HIGH)

* How many **wild animals** can you find?

- Moose, hawk, caribou, bear, ducks, fish, beaver, deer
- Discuss:

  - ° How could the wildlife be impacted by what's around them?
    - ◊ Roads and pipelines fragment (break up) habitat
    - ◊ Infrastructure can pose a hazard (ex. transmission lines can harm birds)
    - ◊ Chemical and physical contaminants in aquatic ecosystems (ex. wetland, river) can impact aquatic animals
    - ◊ People recreating (biking, hiking, fishing) may disturb wildlife

  - ° What can minimize or what is minimizing that impact?
    - ◊ Reclamation of land after a site is decommissioned
    - ◊ Preserving wetland habitat
    - ◊ Establishing parks and protected areas

  - ° Notice the bears. What can be done at an energy site to prevent interactions with bears?
    - ◊ Pack garbage away
    - ◊ Protective fencing to prevent bears from entering the site

  - ° Notice the ducks. Could anything nearby impact the wetland and the ducks swimming there? What can be done to mitigate the impacts?

    - ◊ Consistent water quality monitoring to identify harmful leaks
    - ◊ If water is unsafe for wildlife (i.e. at a tailings pond) - use deterrents like scarecrows or sound cannons

* How many types of **recreation** can you find?

  - ° Bikers, dog walkers, picnickers, campfire, soccer players
  - ° Discuss:

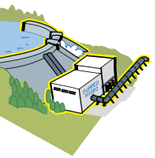
    - ◊ Do you do any of these activities?
    - ◊ How could recreation opportunities be impacted by the energy developments on the poster? What can or is minimizing that impact?

    - ◊ Find the picnickers. What would happen if the Steam Assisted Gravity Drainage site next to them were to expand? If it was up to you, would you expand the site or not?

    - ◊ Find the person fishing. Is there anything happening upstream that could impact the quality of the river and the fish? How could that impact be mitigated?

CONNECTIONS: PLUGGING INTO THE ENERGY LANDSCAPE (JR/SR HIGH)

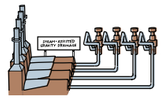
* Find where **water** is being used in the process of generating energy.



- Hydroelectricity – water pressure to spin the turbine, connected to generator to make electricity
- Pumped hydro – reservoir to hold and then release water during times of high demand

- Small modular nuclear reactor - uses water as a coolant
- Oil rig - water is turned into steam and injected underground to liquify the oil so it can be extracted

- Hydrogen – hydrogen can come from water that is goes through electrolysis to separate the hydrogen from the oxygen, or through the process of reforming natural gas which involves steam



- Steam assisted gravity drainage – steam is injected underground to extract oil

- Coal – coal is burned to heat water, which generates steam pressure, used to spin a turbine that is connected to a generator to make electricity
- Geothermal – water that is injected deep underground is warmed by the earth's heat; the water turns to steam as it is pumped back up to the surface, and then used to spin a turbine
- Discuss:
    - What on the poster could impact water quality?
    - What measures could be taken to improve water quality?
    - What technologies use the most water for energy production? The least?

ZAP ZAP: FILL IN THE ENERGY GAPS (JR/SR HIGH)

- The greenhouse gas that is the main driver of climate change is _____
- The colour _____ is used to depict Hydrogen that comes from natural gas
- The colour _____ is used to depict Hydrogen that comes from uranium/nuclear energy
- The "U" in CCUS stands for _____
- The "S" in CCUS stands for _____
- SMNR stands for _____
- Energy can be stored using _____ and _____
- 52.7% of Canada's energy use is from the _____ sector.
- Solar panels use _____ cells to convert energy from the sunlight into electricity.
- Net zero means that the total amount of CO_2 being released into the atmosphere is the _____ amount as is _____.
- Syngas can be transformed into liquid fuels and used to make _____ or to generate _____.
- When organic material breaks down it forms biogas. Biogas is made up of _____ and other gases.
- _____ _____ _____ and _____ are technologies that convert or store carbon dioxide emissions to reduce the amount of CO_2 that is released into the atmosphere.
- Types of biofuels include _____, _____, _____, and _____
- Sustainable aviation fuels have ____% less greenhouse gas emissions compared to fossil fuel based jet fuel.
- A facility near Lethbridge captures the methane from _____ _____ and uses it to generate electricity for Alberta's electrical grid.
- Some Calgary-based companies are integrating CO_2 emissions into the production of _____ and _____.
- All biofuels are _____ _____, but not all synthetic fuels are _____.
- To get hydrogen from water, we use electrolysis to _____ the hydrogen from the oxygen.
- Our use of renewable energy is increasing, which allows us to generate more electricity with _____ greenhouse gas emissions.

ZAP ZAP: FILL IN THE ENERGY GAPS (JR/SR HIGH) -ANSWER KEY

Have your students read the backside of the poster to learn more about climate change, renewable and alternative energy, innovations in fossil fuels and clean fuels.

- The greenhouse gas that is the main driver of climate change is _____ (carbon dioxide)
- The colour ____ (blue) is used to depict Hydrogen that comes from natural gas
- The colour ____ (pink) is used to depict Hydrogen that comes from uranium/nuclear energy
- The "U" in CCUS stands for _____ (utilization)
- The "S" in CCUS stands for _____ (storage)
- SMNR stands for _____ (small modular nuclear reactor)
- Energy can be stored using _____ and _____ (pumped hydro, batteries, compressed air, flywheels…)
- 52.7% of Canada's energy use is from the _____ sector (Industrial).
- Solar panels use _____ (photovoltaic) cells to convert energy from the sunlight into electricity.
- Net zero means that the total amount of CO_2 being released into the atmosphere is the ____ (same) amount as is _____ (removed).
- Syngas can be transformed into liquid fuels and used to make _____ (transportations fuels) or to generate _____ (electricity/heat).
- When organic material breaks down it forms biogas. Biogas is made up of _____ (methane) and other gases.
- ____ ____ _____ and _____ (carbon capture utilization and storage) are technologies that convert or store carbon dioxide emissions to reduce the amount of CO_2 that is released into the atmosphere.
- Types of biofuels include ___, ____, and _____ (ethanol, methanol, biodiesel, butanol)
- Sustainable aviation fuels have ____% (80) less greenhouse gas emissions compared to fossil fuel based jet fuel.
- A facility near Lethbridge captures the methane from ____ (agriculture waste) and uses it to generate electricity for Alberta's electrical grid.
- Some Calgary-based companies are integrating CO_2 emissions into the production of ____ and ____ (soap and concrete)
- All biofuels are _____ (synthetic fuels), but not all synthetic fuels are _____ (biofuels)
- To get hydrogen from water, we use electrolysis to ____ (separate) the hydrogen from the oxygen.
- Our use of renewable energy is increasing, which allows us to generate more electricity with ___ (less) greenhouse gas emissions.

POWER QUEST: ENERGY SOURCE RESEARCH PROJECT (JR/SR HIGH)

This activity will explore the natural resources in Alberta and Canada that are used to produce energy and evaluate the opportunities and challenges of each from social, economic and environmental perspectives. There are 8 different natural resources for energy displayed on the Energy Innovation Poster. Have your class study the poster to find all 8 sources (solar, wind, hydro, geothermal, biomass, oil, natural gas and uranium).

Have each group pick an energy source and conduct research to answer the following questions:

- What is the energy source? Is it renewable or nonrenewable?
- Where is it found in Alberta/Canada?
- How is the source used to produce energy? Describe the process.
- Investigate the environmental, economic and societal costs and benefits of developing the source for energy.
- What are some of the challenges of the energy source that might limit its widespread use?
- Compare the use of the energy source across Canada - which provinces or territories use it the most and why?
- Explore technology and innovation in the generation of electricity from the energy source. How has the use of this source changed over the last 30 years? Will it continue to change?
- What careers are involved with this energy source? Would you be interested in any of those careers?
- Identify stewardship actions (personal, school, community, provincial, federal, and/or global) that contribute to energy conservation and efficiency in relation to the energy source.

Hydrogen

- **Research**:
    - The Hydrogen landscape is quickly evolving. Have your students research Hydrogen and present to the class on a new local story, company or use of Hydrogen they find.
    - Alberta is focusing largely on Blue Hydrogen (Hydrogen from natural gas that is accompanied by carbon capture) and Grey Hydrogen (Hydrogen from natural gas that is not accompanied by carbon capture), but other countries are focusing more on Green Hydrogen (Hydrogen from renewable resources). Have your students research what Hydrogen looks like in other parts of the world (Europe and Asia are good places to start) and present to the class on what they find.
- **Do**:
    - Build a hydrogen fuel cell car model - you can source hydrogen fuel cells from companies such as Horizon Educational and Arbor Scientific
    - Electrolysis demo - instructions:

Hydrogen doesn't exist by itself in nature, so it is typically obtained through the process of reforming (*heating*) or electrolysis (*splitting water*). This experiment will show you how hydrogen can be produced through electrolysis - the splitting of water into its two main elements - hydrogen and oxygen.

Instructions:

1. Insert two metal push pins into the plastic cup (sharp points facing into the cup) *insert the same distance apart as the hubs on the 9V battery
2. Fill the cup about half full with water
3. Mix a pinch of baking soda into the water
4. Place the cup on top of the 9V battery (the metal push pins should be touching the battery hubs)
5. Observe the tops of the push pins - what do you see happening?

What is happening?

Electricity is flowing through the water, which breaks up the water (H_20) into its components - hydrogen gas and oxygen gas. You can tell the gases are forming from the bubbles flowing upward from the battery hubs. There will be twice as much hydrogen gas as oxygen gas (remember it is H_20!), so the battery hub with more bubbles is the hydrogen.

Extention:

1. Baking soda works as an electrolyte when mixed with water, so it allows an electric current to flow through. Try the experiment with different solutions:

    - Does it work with lemon juice? Salt water? Distilled water? Tap water?
    - Remember, an electrolyte solution is needed to carry a current and form gas. Salt water and lemon juice water should work well. Distilled water should not produce any current at all, whereas tap water will likely produce a small amount of gas because it contains some minerals and impurities. Try out these solutions and find out for yourself!

POWER QUEST: ENERGY INNOVATION RESEARCH PROJECT (JR/SR HIGH)

Carbon Capture

- **Research**:
    - Carbon capture is quickly evolving and advancing around the globe. Research carbon capture and present to the class on a carbon capture project, company or news story you come across.
    - One of the places carbon capture innovations are tested is at the Alberta Carbon Capture Technology Center in Calgary - look it up to read about some of the innovative ways carbon dioxide is being used locally.
- **Do**:
    - Design a carbon capture project. Imagine you've founded a start-up that is capturing carbon dioxide and using it to make an innovative project. What would the product be? How would you go about capturing the carbon needed to make your product? "Pitch" your product to the class!

Biogas

- Purchase a MudWatt microbial fuel cell (companies including Flinn Scientific Canada and Boreal Science carry them) to explore how we can generate electricity from biomass (organic waste) such as soil, mud, compost, etc.
    - Did you know that bacteria found in soil can be used to generate electricity? Microbial Fuel Cell technology allows bacteria to digest sugars and release electrons, generating an electric current. This technology is used in water treatment plants to clean wastewater and generate electricity.
    - Use your MudWatt to experiment with different types of biomass (organic waste) - does soil, mud, or compost work best? What adaptations can you make to increase the speed or the amount of electricity generated?
    - Where could you see this type of technology being useful? ***look up uses in space and deep water*

ENERGY STORAGE DESIGN CHALLENGE (JR/SR HIGH)

Energy storage is increasingly important as more intermittent resources, such as solar and wind, are added to the electrical grid. Energy storage allows energy to be stored when demand is low and then released when demand is high. There are many forms of energy storage, and it is a sector that is seeing lots of research and innovation.

- Find the **pumped hydro station**. Is there any impact from pumped hydro on land, air or water? What are the advantages and disadvantages of pumped hydro?
- Find the **battery storage station**. Where do the minerals used to make the batteries come from? What are the advantages of battery storage? What are the disadvantages of battery storage?
- Have your students research other forms of energy storage - compressed air, flywheels, thermal energy storage.
- Have your students pick a form of energy storage - or invent their own - and design a prototype. Draw it or build it using materials found in the classroom and present it to the class.

FOLLOW THE FLOW OF ENERGY (ELEMENTARY &JR/SR HIGH)

Now that you've learned about the different energy sources, develop a story illustrating the travels of one atom, going from the raw energy source to the energy being used. Present this story to the class. Be creative in this presentation, and in the adventures that the main character has. You can present this story in a variety of creative ways. For example:

- Art (e.g. a cartoon, or diagram)How is the source used to produce energy? Describe the process.
- Music (a song)
- Multimedia (e.g. a slide show)
- Drama (a play)
- Writing (a poem, or a story)
- The story of each molecule's adventure must include at least:
    - Where the raw resource came from
    - How the raw resource was extracted
    - Any changes in the form of energy (i.e. kinetic to electrical, mechanical to thermal, etc.) that happened
    - How the energy was transported
    - How the energy was used

ENERGY BUMPER STUMPERS (JR/SR HIGH)

Hand this out to your students and have them work individually or in groups to solve the Energy Bumper Stumpers.

This plate is one of the reasons it's important to learn about energy.

This plate is what we are talking about today!

This plate is a term for natural resources such as solar, wind, hydro, or nuclear.

This plate refers to a fuel produced from a renewable resource.

This plate refers to the term for the natural resources with an unlimited supply.

This plate names a type of renewable energy that is quickly on the rise in Alberta.

This license plate refers to technology that can be used to reduce CO2 emissions.

This plate refers to when pulp mills use syngas produce both electricity and heat.

This plate is the term for the carbon-based fuels that are abundant in Alberta.

This plate refers to the source of a nonrenewable energy that is not a fossil fuel.

This plate describes the energy (heat) from within the earth.

This plate relates to Canada's energy & climate goals for 2050.

ENERGY BUMPER STUMPERS (JR/SR HIGH)

This license plate refers to the most abundant element in the universe that can also be used for electricity.

This plate is the term for the mixture of hydrogen and carbon monoxide that is created using lots of chemistry!

This plate refers to the process that uses electricity to separate the hydrogen from the oxygen in a water molecule.

This plate is refers to what we use to store energy.

This plate identifies the types of fuels that emit less CO2 than carbon-based fuels

This plate relates to Canada's energy & climate goals for 2050.

This plate refers to a common greenhouse gas that contributes to climate change.

This plate identifies the molecules that cause climate change.

This plate names a type of reactor that can supply zero-emission energy to industrial sites.

This plate refers to another name for a windmill.

ENERGY EYE SPY (ELEMENTARY)

This activity is designed to familiarize your students with some of the terms on the Energy Innovation Poster. Divide the class into small groups and provide each group with a copy of the poster. Have each group come up with a sound or catchy word that relates to energy. For example, "Zap!" This will be their team name and 'buzzer'. Read the following natural resource riddles and energy innovation eye spy items and award points to the first group that correctly comes up with the answer and finds the corresponding item on the poster. Groups can indicate that they have the answer by shouting out their energy word or sound.

Natural Resource Riddles

* I am big and round and very bright
  You will see me by day but never at night
  A panel collects the energy from me
  I am a renewable resource with lots of energy

* I am the energy found in moving air
  The faster I blow the more I mess up your hair
  In Southern Alberta you might see turbines spin
  When we use this source of energy, it's a win

* Drip, drop, from streams and rivers I flow
  I'm the largest source of renewable energy you know
  You need to drink me to stay alive
  But did you know about all the power I provide?

* I am a product from trees and a source of fuel
  I can be burned for energy, isn't that cool?
  Toss me in the fire and I will create lots of heat
  To keep you warm or cook the food you eat

* From a hard pellet smaller than a hand
  We create power from a rock mined from the land
  It can cost lots of money and the waste doesn't go away
  But the air stays clean and that's why it's here to stay

* I'm thick and black and under the ground
  North and East of Edmonton is where I'm found
  I'm all mixed in with the sand, water and clay
  Did you know that you use my products every day?

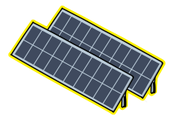
* You cannot see me, I am like invisible oil
  Pumped up from the earth far beneath the soil
  I fuel your furnace to keep your house full of heat
  I was formed from ancient plants and animals, isn't that neat!

* I come from the earth, deep below your feet
  I can be used to make electricity or fill your house with heat
  Under hot springs I can often be found
  To use me drill wells deep into the ground

ENERGY EYE SPY (ELEMENTARY) - ANSWER KEY

Natural Resource Riddles

* I am big and round and very bright
  You will see me by day but never at night
  A panel collects the energy from me
  I am a renewable resource with lots of energy

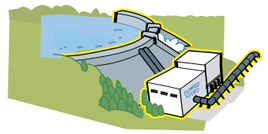


- ***Solar panels (solar farm, rooftop solar array)*** - Photovoltaic cells convert solar energy into electrical or thermal energy. Lots of them together can generate enough electricity to power entire towns! Solar panels on a rooftop can help make a building net zero.

* I am the energy found in moving air
  The faster I blow the more I mess up your hair
  In Southern Alberta you might see turbines spin
  When we use this source of energy, it's a win

- ***Wind turbine*** - The power of the blowing wind turns turbines that generate electricity.

* Drip, drop, from streams and rivers I flow
  I'm the largest source of renewable energy you know
  You need to drink me to stay alive
  But did you know about all the power I provide?



- ***Hydroelectric dam*** - Water flowing down a river pushes turbines to generate electricity.
- ***Pumped hydro facility*** - When there is excess electrical energy, water is pumped from a lower reservoir to a higher reservoir. When the electricity is needed, water in the higher reservoir is released so it flows down to turn a turbine and generate electrical energy.

* I am a product from trees and a source of fuel
  I can be burned for energy, isn't that cool?
  Toss me in the fire and I will create lots of heat
  To keep you warm or cook the food you eat

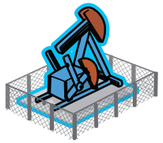
- ***Biomass plant (at pulp mill)*** - Organic waste such as wood chips or crop residue can be burned or gasified for energy.

ENERGY EYE SPY (ELEMENTARY) - ANSWER KEY

* From a hard pellet smaller than a hand
We create power from a rock mined from the land
It can cost lots of money and the waste doesn't go away
But the air stays clean and that's why it's here to stay

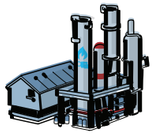
- ***Small modular nuclear reactor*** - This nuclear fission reactor can be used to power oil and gas extraction operations or provide electricity for communities.

* I'm thick and black and under the ground
North and East of Edmonton is where I'm found
I'm all mixed in with the sand, water and clay
Did you know that you use my products every day?



- ***Oil pump*** - Oil is made into products like gasoline, diesel, asphalt and plastics.

* You cannot see me, I am like invisible oil
Pumped up from the earth far beneath the soil
I fuel your furnace to keep your house full of heat
I was formed from ancient plants and animals, isn't that neat!



- ***Natural gas plant*** - Natural gas makes up most of Alberta's electricity generation.

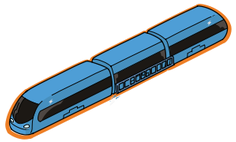
* I come from the earth, deep below your feet
I can be used to make electricity or fill your house with heat
Under hot springs I can often be found
To use me drill wells deep into the ground

- ***Geothermal well*** - Heat from deep below the earth's surface is used to generate electricity and heat.

ENERGY EYE SPY (ELEMENTARY)

Energy Innovation Eye Spy - Questions:

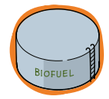
* Battery storage



* High speed train

* Sustainable aviation fuel truck

* Biofuel storage tank



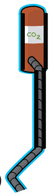
* Renewable natural gas storage tank

* Hydrogen bus

* Hydrogen heating tank

* Carbon technologies building

* Clean air bus



* Carbon pipeline

* Carbon capture storage hub

* Research centre

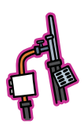
* Water monitoring station

* Soil monitoring station

* Air quality monitoring station

* Snowpack monitoring station

* Hydrogen Sulphide (H_2S) monitor

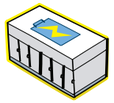


* Landfill monitor

ENERGY EYE SPY (ELEMENTARY) - ANSWER KEY

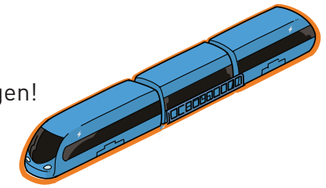
Energy Innovation Eye Spy

* **Battery storage**



- Batteries can store excess electrical energy as chemical potential energy, which can then be converted back to electrical energy when it is needed.

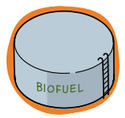
* **High speed train**
    - This could be powered by electricity or hydrogen!



* **Sustainable aviation fuel truck**

- Sustainable Aviation Fuels are made from residual raw materials like cooking oil, and they have 80% less greenhouse gas emissions compared to fossil fuel based jet fuels. ("Sustainable Aviation Fuel | Decarbonisation")

* **Biofuel storage tank**



- A biofuel is a liquid fuel that is produced from a renewable resource. Biofuels can be produced from a variety of sources including wood chips, plants, animal fats, food waste, crop residues or even algae!

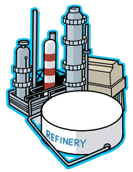
* **Renewable natural gas storage tank**

- When organic materials decompose, methane is released - we call this methane biogas. The methane can be captured and turned into renewable natural gas.

* **Hydrogen bus**

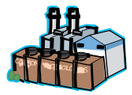
- This bus is powered by hydrogen fuel.

* **Hydrogen heating tank**



- Hydrogen is blended into natural gas for heating.

* **Carbon technologies building**

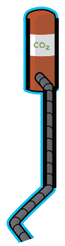


- Carbon dioxide is turned into products like soap, concrete and even hockey sticks!

* **Clean air bus**

- The fuel powering this bus comes from natural gas.

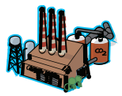
* **Carbon pipeline**



- This pipeline is transporting carbon dioxide to the carbon capture storage hub.

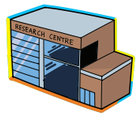
ENERGY EYE SPY (ELEMENTARY) - ANSWER KEY

* **Carbon capture storage hub**



- Carbon dioxide is liquefied and injected underground to be stored.

* **Research centre**



- Research and development is where all of these innovative technologies begin!

* **Water monitoring station**

- This water monitoring station could be testing pH, flow rate, sediment composition, chemicals (nitrates/nitrites/phosphates), temperature, etc. to determine if the upstream activities are having an impact on water quality and quantity.

* **Soil monitoring station**

- This soil monitoring station could be measuring pH, temperature, texture (silt/sand/clay), chemicals, etc. to determine if the surrounding activities and changing climate are having an impact on soil quality.

* **Air quality monitoring station**

- This air quality monitoring station could be measuring particulate matter (PM2.5 and PM10), carbon dioxide, carbon monoxide, nitrous oxides, sulphur dioxide, temperature, etc. to measure and track air quality throughout the year.

* **Snowpack monitoring station**

- This snowpack monitoring station could be measuring snow depth, temperature, ice pack, etc. to determine if and how the snowpack is changing over time.

* **Hydrogen Sulphide (H_2S) monitor**

- Hydrogen Sulphide monitors are important for safety because they alert workers if Hydrogen Sulphide levels are above a threshold.

* **Landfill monitor**

- Landfill monitors sample and landfill gas for its methane, carbon dioxide, nitrogen and oxygen concentrations.

POWER QUEST: ENERGY SOURCE RESEARCH PROJECT (ELEMENTARY)

This activity will explore the natural resources in Alberta and Canada that are used to produce energy and evaluate the opportunities and challenges of each from social, economic and environmental perspectives. There are 8 different natural resources for energy displayed on the Energy Innovation Poster. Have your class study the poster to find all 8 sources (solar, wind, hydro, geothermal, biomass, oil, natural gas and uranium).

Have each group pick an energy source and conduct research to answer the following questions:

- What is the natural resource called?
- Is it renewable or non-renewable?
- Where is the natural resource found?
- How is the natural resource used to produce energy? Describe the process.
- What are the advantages of using this natural resource? (think about the environment, economy, social factors, population sizes, etc.)
- What are the disadvantages of using this natural resource?
- Compare the use of the energy source across Canada - which provinces or territories use it the most and why?
- Do you think we should use more or less of this natural resource?
- What careers are involved with this energy source? Would you be interested in any of those careers?
- Identify stewardship actions (personal, school, community, provincial, federal, and/or global) that contribute to energy conservation and efficiency in relation to the energy source.

SPARKING SOLUTIONS (ELEMENTARY)

Find the items listed below on the front of the Energy Innovation poster and use the Code Breaker to solve the puzzle!

1. **# band offices + # bears + # reclamation areas**
2. **# people with hard hats x Steam-assisted gravity drain pipes**
3. **(# recycle bins + # electric cars) x # cows**
4. **# of caribou x # ducks**
5. **(H_2 symbols x CO_2 symbols) + (CH4 symbols x Li symbols)**
6. **# charging electric vehicles x # of people canoeing on the river**
7. **# solar panels on the school - # of types of fuel at the fueling station**
8. **5 (S)**
9. **# people biking + # trains - # cars driving on the road**
10. **# dogs + # hockey sticks**
11. **# solar panels / # geothermal wells**
12. **7 (I)**
13. **# solar panel / # planes**
14. **18 (A)**
15. **# Cogeneration facilities + # cows**
16. **20 (T)**
17. **7 (I)**
18. **# wind turbines x # oil pump jacks**
19. **14 (N)**

Code Breaker:

A = 18	F = 58	K = 0	P = 28	U = 82	Z = 46
B = 30	G = 99	L = 54	Q = 29	V= 66	
C = 8	H = 2	M = 73	R = 4	W = 12	
D = 3	I = 6	N = 14	S = 17	X = 97	
E = 35	J = 59	O = 9	T = 20	Y = 75	

_ _ _ _ _ _ _S_ _ _ I_ A_TI_N

SPARKING SOLUTIONS (ELEMENTARY) - ANSWER KEY

Answer Key:

- # band offices + # bears + # reclamation areas → 2+2+1 = 5
- # people with hard hats x Steam-assisted gravity drain pipes → 5x4 = 20
- (# recycle bins + # electric cars) x # cows → (3+2)x7 = 35
- # of caribou x # ducks → 3x4 = 12
- (H_2 symbols x CO_2 symbols) + (CH4 symbols x Li symbols) → (8x2) + (2x1) = 18
- # charging electric vehicles x # of people canoeing on the river → 2x2=4
- # solar panels on the school - # of types of fuel at the fueling station → 6-3= 3
- 5 (S)
- # people biking + # trains - # cars driving on the road → 4 +1 - 3 = 2
- # dogs + # hockey sticks → 2 + 5=7
- # solar panels / # geothermal wells → 28 / 1 = 28
- 7 (I)
- # solar panel / # planes→ 28/2 = 14
- 18 (A)
- # Cogeneration facilities + # cows → 1+7=8
- 20 (T)
- 7 (I)
- # wind turbines x # oil pump jacks → 3x3 = 9
- 14 (N)

A = 18	F = 58	K = 0	**P = 28**	U = 82	Z = 46
B = 30	G = 99	L = 54	Q = 29	V= 66	
C = 8	**H = 2**	M = 73	**R = 4**	**W = 12**	
D = 3	**I = 6**	**N = 14**	**S = 17**	X = 97	
E = 35	J = 59	**O = 9**	**T = 20**	Y = 75	

ANSWER: STEWARDSHIP IN ACTION

SUPPLIMENTAL ACTIVITIES:

* Go to https://www.insideeducation.ca/learning-resources/ and search for the following resources:

  - Our Energy Future - This activity challenges students to consider the social, economic and environmental factors associated with the natural resources used for electricity generation across Canada.
  - Energy Dialogues - The Energy Dialogues interactive site allows students to view a series of videos that explore topics such as wind energy and hydraulic fracturing. The series culminates with a roundtable discussion and guiding questions that encourage critical thinking and analysis of current environmental and natural resource issues.
  - Energy Efficiency and Conservation - Students will examine energy conservation and efficiency in their own home and community by conducting their own home energy audit and taking stock of their individual conservation behaviours.How the energy was transported
  - Evaluating Energy Resources - This independent research activity guides students through identifying opportunities, challenges and emerging technologies associated with the natural resources used in electricity generation in Canada.
  - The Energy Around Us Scavenger Hunt - This scavenger hunt challenges students to identify objects that consume energy in their neighborhoods and homes, while learning ways to practice energy stewardship in their daily lives.

"AESO 2023 Annual Market Statistics." AESO, 1 March 2024, https://www.aeso.ca/assets/Uploads/market-and-system-reporting/Annual-Market-Stats-2023_Final.pdf. Accessed 27 March 2024.