lesson plan

How Green is Canada's Electricity?

Which source of energy used in electricity generation in Canada is the most environmentally responsible, given equivalent output?

overview

LESSON CONTEXT

Canada has a strong energy mix; however, there are rising concerns that a number of these energy sources produce greenhouse gases which contribute to global warming. Nuclear power claims to hold "the greatest promise of generating enough electricity to meet our continually rising needs while being the most environmentally responsible."

LEARNING GOALS

- Identify renewable and non-renewable sources of energy used in electricity generation.
- Understand that each method of electricity generation has both costs and benefits.
- Evaluate evidence and consider alternative perspectives, ideas and explanations.

LEARNING ACTIVITIES

In this lesson, students will research the various forms of energy used to generate electricity in Canada (i.e. nuclear, hydro, fossil fuels, wind and solar) with a particular focus on energy from nuclear power generation and complete a cost-benefit analysis of these sources.

BIG IDEAS

A responsible and effective energy strategy for electricity generation involves diverse energy sources, each with its own unique set of environmental implications. These implications can involve air and water quality, habitat impact and the possibility of catastrophic failure.

time
60-75
MINUTES PLUS TIME OUTSIDE OF CLASS

subjects
SCIENCE
ENVIRONMENTAL SCIENCE
TECHNOLOGY

skills
CRITICAL THINKING
COMMUNICATION

assessment & evaluation

PRIOR KNOWLEDGE AND SKILLS

- Awareness of energy sources used to generate electricity
- Experience locating legitimate information using internet sources
- Experience doing cost-benefit analyses
- Experience working in cooperative small groups

SUCCESS CRITERIA

- Students participate in meaningful class discussions
- Student cost-benefit analysis demonstrates understanding of trade-offs inherent in electricity generation

ASSESSMENT STRATEGIES

- Review of **Energy Source Cost-Benefit Analysis Self-Assessment BLM**
- Review of **Energy Source Cost-Benefit Analysis Template BLM**

resources & materials required

- DOC PDF **BLM – Energy Source Cost-Benefit Analysis Self-Assessment** – one per student
- DOC PDF **BLM – Sources of Electricity Web Links** – one per student
- DOC PDF **BLM – Energy Source Cost-Benefit Analysis Template** – one per group of two to three students
- PDF **BLM – Energy Source Cost-Benefit Analysis Learning Strategy** – for teacher use
- PDF Curriculum alignment
- Student notebooks
- Electronic devices with internet access

minds-on

20 MINUTES

- Begin a discussion about the most important environmental concerns of today. Global warming and greenhouse gas emissions will likely be at the top of the list.
- Brainstorm a list of causes of global warming. This does not have to be an exhaustive or researched list.
- In all likelihood, students will identify pollution from the burning of fossil fuels such as petroleum and coal as important factors. Discuss with students why these fuels are burned. In Canada, the burning of these fuels, especially coal, is used to generate electricity (In 2017, 9% of Canada's electricity generation came from the burning of coal).
- Brainstorm a list of energy sources used to generate electricity in Canada. This should include hydro, nuclear, fossil fuels (oil, natural gas, coal) and renewable sources (solar, tidal, biomass, wind). Each of these sources can be explored from an environmental perspective in terms of its costs and benefits.

action

20 MINUTES PLUS TIME OUTSIDE CLASS

PART I – WHOLE CLASS

- Students will be completing an environmental cost-benefit analysis for an energy source. Assign one energy source (sources identified during the brainstorming) which is used to produce electricity to each small group of students and provide the group with the **Energy Source Cost-Benefit Analysis Template BLM**.
- To make the comparison of the energy sources fair, each group will calculate the number of plants or units (e.g. wind turbines, dams, etc.) which would be required to generate 500 MW of energy. Students will make this calculation using the nameplate capacity of each electricity generation technology from the box at right. Provide the students with this data and explain that nameplate capacity is the maximum amount of energy that a given electricity generation technology can produce under optimal conditions.

  For most groups this will be simple. For 500 MW you would need:

  » one large coal-fired generating station;

  » one large natural gas-fired plant; or

  » one large hydroelectric generating station.

DID YOU KNOW?

Nameplate Capacities*

Large coal-fired generating station
= ~500 MW
(e.g. Sundance A Power facility [AB], 560 MW)

Large natural gas-fired unit
= ~500 MW
(e.g. Lennox Generating Station [ON], 2,120 MW for four units)

Medium nuclear reactor
= ~650 MW
(e.g. Point Lepreau Generating Station [NB], 680 MW)

Large hydroelectric generating station
= ~500 MW
(e.g. Kootenay Canal Generating Station [BC], 580 MW)

Wind turbine
= ~2 MW
(e.g. Centennial Wind Power Facility [SK], 1.8 MW)

Solar panels
= ~100 W

** See Background Information for sources.*

The groups who will analyze nuclear, wind and solar technologies will have to do some calculating.

For 500 MW you would need:

» 500 MW ÷ 650 MW/nuclear reactor = 0.77 nuclear reactors;

» 500 MW ÷ 2 MW/wind turbine = 250 wind turbines; or

» 500 MW ÷ 100 W/solar panel = 5,000,000 solar panels.

- These values will need to be recorded on each group's **Energy Source Cost-Benefit Analysis Template BLM**.
- For their cost-benefit analyses, the students will need to take into consideration the fact that no technology which produces electricity runs at its nameplate capacity 100% of the time.
- The percentage of time that a given technology produces its nameplate capacity is called its capacity factor. For example, if an energy source produces electricity 50% of the time then its capacity factor is 50%.
- Discuss the following questions:

  » *Why do you think coal, hydro, nuclear and natural gas power plants only run at their nameplate capacity 90% of the time?*

  Power plants are sometimes shut down for routine maintenance, upgrades, etc.

  » *Why do you think wind turbines have a 25% capacity factor?*

  Wind turbines can only run when the wind is at the right speed (cannot run if the wind is too strong or not strong enough, or not blowing), turbines can also be shut down for maintenance, upgrades, cleaning, etc.

  » *Why do you think solar panels only have a 10-15% capacity factor?*

  Solar panels only run on sunny days and cannot run at night. They also need to be cleaned on a regular basis as they are less effective when dirty.

- As a class, review the process of completing a cost-benefit analysis (see full learning strategy description on the **Energy Source Cost-Benefit Analysis Learning Strategy BLM**).
- Brainstorm a list of environmental criteria that all groups will use to assess the benefits and costs.
- These should include criteria such as air quality, habitat impact, possibility of catastrophic failure, management of waste, impact of catastrophic failure, availability of raw materials, procurement of raw materials, transportation of raw materials, etc. You, or the students, may come up with other criteria. They should write these criteria on their template in the appropriate column.
- Do not discuss whether the criteria are costs or benefits or have the students discuss these at this point. Students need to decide about each criterion themselves based on their research evidence. If students are unsure whether the criterion is a benefit or a cost, they may use the unsure column.
- For each of the criteria, students will need to describe the criterion in terms of the specific benefits or costs for their energy source (e.g. in terms of air pollution, nuclear reactors produce no greenhouse gases this would be cited as a benefit for nuclear power). They will also need to provide justification for the weighting of each cost or benefit; this will be based on their research evidence.
- Provide each student with a copy of the **Energy Source Cost-Benefit Self-Assessment BLM** and review the criteria. This is a self-assessment which provides criteria for the task.

PART II – SMALL GROUP ACTIVITY

- Students will research their energy source either in the computer lab during class time or using the internet outside of class time. There are sources of information for students to use on the **Sources of Electricity Web Links BLM**. Students may also choose to locate other sources through web searches.

IMPLEMENTATION OPTIONS

- You may wish to provide the students with the criteria that are most relevant to your jurisdiction's curricula.
- Students could focus only on those energy sources that are used to generate electricity in their own province.
- As part of their research, students can watch the videos on how electricity generation works in the multimedia section of the Ontario Power Generation website.

consolidation

20 MINUTES

- Provide each of the groups with the opportunity to present the findings from their cost-benefit analyses to the class. Record the overall totals as a class on a chart (e.g. use blackboard, whiteboard, overhead, computer, etc.).
- Discuss the data in the chart both horizontally and vertically. Questions for discussion could include:
  - » *Is a cost-benefit analysis objective or subjective?*
  - » *Is there any definitive 'best' form of energy for electricity generation?*
  - » *If you were in a position of authority, how could you use this information?*
  - » *How does capacity factor affect your analysis?*
  - » *Where would your energy come from at night if you based an energy system on solar energy?*
  - » *Where would your energy come from on a calm day if you based an energy system on wind energy?*
  - » *Why would a responsible and effective energy strategy involve using different energy sources?*

IMPLEMENTATION OPTION

- Students could report their findings orally or in an alternate format, such as a poster or a PowerPoint presentation.

additional resources

CANADIAN NUCLEAR ASSOCIATION WEB PAGES

- **Climate change**
- **Life-cycle emissions**
- **Emissions research**

RELATED TEACHNUCLEAR LESSON PLANS

- **Costs & Benefits of Electricity Generation**
- **Baseload vs. Peak Demand**

VIDEOS

- **Solar Energy – SciShow**
- **Energy 101: Solar Power – energynownews**
- **Energy 101: Wind Power – energynownews**
- **Energy 101: Marine and Hydrokinetic Energy – U.S. Department of Energy**
- **Nuclear Power: How it Works – opgvideos**
- **Hydroelectric Power: How it Works – opgvideos**

background information

(Retrieved August 2019)

- **Canadian Association of Petroleum Producers**
  Issues and initiatives, as well as environmental stewardship, relating to petroleum products.
- **Canadian Gas Association**
  Information about natural gas in Canada.
- **Power Generation in Canada: A Guide – Canadian Electricity Association**
  This guide has charts, graphs and information that compares electricity generation technologies.
- **WaterPower Canada**
  WaterPower Canada represents the hydropower industry in Canada.
- **Canadian Solar Industries Association**
  Information about the solar energy industry and issues.
- **Canadian Wind Energy Association**
  Information about wind energy and wind farms including data on energy generation from wind (in MW) per province.
- **Coal Association of Canada**
  Learn about the coal industry in Canada.
- **Greenhouse gas emissions: inventories and reporting – Environment and Climate Change Canada, Government of Canada**
  Links to information about Canada's national, provincial and facility-reported greenhouse gas emissions.
- **CanmetENERGY – Natural Resources Canada, Government of Canada**
  CanmetENERGY is Canada's leading research and technology organization in the field of clean energy.
- **Ministry of Energy, Northern Development and Mines, Government of Ontario**
  Information about Ontario's electricity system, the mineral sector, and northern economic and community development.
- **Powering the next generation – Ontario Power Generation**
  Educational resources about the complex world of energy, including videos and other learning resources, developed for teachers and students in grades 1, 6 and 9.

SOURCES REFERENCED ON PAGE 2

Sundance A Power facility (AB)

Lennox Generating Station (ON)

Point Lepreau Generating Station (NB)

Kootenay Canal Generating Station (BC)

Centennial Wind Power Facility (SK)