lesson plan

Costs & Benefits of Electricity Generation

Which source of energy used in electricity generation in Canada best addresses Canada's electrical energy needs?

overview

LESSON CONTEXT

Canada gets its electricity from a mix of energy sources – some renewable (e.g. wind, solar, hydro, etc.) and some non-renewable (e.g. coal, oil, natural gas and nuclear). However, there are concerns about some of the energy sources used to generate electricity. Concerns can be social (e.g. having wind turbines nearby), economic (e.g. the cost of building a new nuclear reactor), environmental (e.g. carbon emissions from a coal-fired generating station) or, in some cases, all three.

LEARNING GOALS

- Analyze from a variety of perspectives the impact of electric power generation on society, the economy and the environment.
- 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 sources of energy used to generate electricity in Canada 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 social, economic and environmental implications.

time
60-75
MINUTES PLUS TIME OUTSIDE OF CLASS

subjects
SCIENCE
ENVIRONMENTAL SCIENCE
SOCIAL STUDIES

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

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

minds-on

10 MINUTES

Have students brainstorm a list of energy sources used to generate electricity in Canada. Students should record these energy sources in their science notebooks. This list should include renewable (hydro, wind) and non-renewable (nuclear, natural gas, coal) energy sources. Discuss where they have seen examples of each in their province.

action

20 MINUTES PLUS TIME OUTSIDE OF CLASS

PART I – WHOLE CLASS

- Students will be completing a cost-benefit analysis of one energy source from a given point of view. Assign students in groups of two or three to each of the topics on the chart below.

Energy Source	Social	Economic	Environmental
Coal	Group 1	Group 7	Group 13
Hydro	Group 2	Group 8	Group 14
Natural Gas	Group 3	Group 9	Group 15
Nuclear	Group 4	Group 10	Group 16
Wind	Group 5	Group 11	Group 17
Solar	Group 6	Group 12	Group 18

- Provide each group with a copy of 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 the **Energy Source Cost-Benefit Analysis Learning Strategy BLM**). Determine criteria that could be used by each group's perspective to assess the benefits and costs.
- Criteria could include:
  - » Social Perspective: location (living near a nuclear plant, having a wind turbine on your property), emissions, lights, noise, effects on recreation and aesthetics, etc.
  - » Economic Perspective: operating costs (cost of fuel, maintenance, staff, waste disposal, carbon tax), capital costs (cost to construct), life cycle, etc.
  - » Environmental Perspective: 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.
- Students should write the criteria specific to their perspective on their template in the appropriate column.
- Do not discuss whether the criteria are costs or benefits 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 criterion, students will need to describe the specific benefits or costs for their energy source. They will also need to provide justification for the weighting of each cost or benefit; this will be based on their research evidence.
- Provide students with the **Energy Source Cost-Benefit Analysis Self-Assessment BLM** and review the criteria. This is a self-assessment that provides criteria for the task.

PART II – INDIVIDUAL STUDENT ACTIVITY

- Students will research their energy source from their perspective either during class time or using the internet outside of class time.
- There are sources of information to get students started on the **Sources of Energy Web Links BLM**; they 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

30 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 such as the one in the ACTION section (e.g. use blackboard, whiteboard, overhead, computer, etc.).
- Discuss the data in the chart both horizontally and vertically. Questions for discussion should 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
- Power rates
- Life-cycle costs
- Safety record
- Operational safety
- Plant security
- Baseload supply
- Dependable resource

RELATED TEACHNUCLEAR LESSON PLANS

- How Green is Canada's Electricity?
- Baseload vs. Peak Demand

VIDEOS

- Energy 101: Solar Power – energynownews
- Energy 101: Wind Power – energynownews
- Energy 101: Marine and Hydrokinetic Energy – U.S. Department of Energy
- How is Electricity made? – ONgov
- 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 Canadian hydropower industry.
- **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)