ARE NET-ZERO BUILDINGS POSSIBLE? (SVN3E)

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Grade Level/Course Code: SNC3E -Grade 11 Science, Workplace

Overview: This learning experience can be used as a culminating activity (in lieu of a final exam) or as a project that covers a number of strands. In an attempt to find out if it is possible to build a building (e.g. a home, school, office, shopping mall, etc.) that can be net-zero or reasonably close to, students will research the energy associated with different features of a building. Suggested buildings are houses or schools. In doing so, students will also gain an understanding of why the goal of net zero buildings is a good one. The end result will be that students will be able to compare the energy required to run a conventional building compared to a very efficient/net zero one. Students will also design or redesign the building of their choice with features that would lead to a net zero/carbon neutral building. The building can be presented in a number of formats and students can share their findings as well as report on their building more formally as in a report or less formally as in an interview. Since net zero focuses on energy consumption, the students can only focus on this aspect, but they can extend it to include water consumption, waste management and indoor air quality.

Inquiry focus:

Considering the energy that a building uses and what goes into building and running it, is it possible to have it be net zero or very close to this goal (i.e. can the building produce as much as it consumes)? To make this project accessible for all students, there can be different levels of inquiry:

1. Teacher guided inquiry, whereby the teacher provides energy consumption values for the particular type of home that a student wants to work on (e.g. single family home or apartment) and provides a template of a home that features can be added to.
2. Teacher guided inquiry, whereby the teacher facilitates the research by providing specific websites and the choice of buildings is limited to a home or a school.
3. A significant degree of independent research into the carbon footprint of the building type chosen, the energy efficiency features and the design.

Big ideas:

The following big ideas are all addressed to a greater or lesser extent.

Human Impact on the Environment (this is the reason for building low-carbon or no-carbon buildings (i.e. global warming/climate change; background learned prior or during the project)

- The biotic elements of an ecosystem include humans.
- Abiotic and biotic factors interact within an ecosystem.
- People have positive and negative effects on the environment, both locally and globally.

Energy Conservation (what energy sources to use, calculating energy use, etc. - also background information learned prior to or during project)

- The impact of energy production and consumption on environmental sustainability, depends on which resources and energy production methods are used.

Natural Resource Science and Management (e.g. the use of sustainable resources, local resources - this could be an extension to the project for some students who want to add the perspective of reduced energy from the sourcing of local materials)

- Careful resource management planning is necessary to sustain ecosystems.

Strands and Units:

Energy Conservation, Human Impact on the Environment, Environmental impact on Human Health

Strand B: Human Impact of the Environment

Overall Expectation - B1: Students analyse selected current environmental problems in terms of the role human activities have played

Specific Expectation - B1.1: Students propose possible solutions, on the basis of research, to a current practical environmental problem that is caused, directly or indirectly, by human activities in creating or perpetuating them, and propose possible solutions to one such problem. (energy use of buildings)

Overall Expectation - B2: Students will investigate air, soil, and water quality in natural and disturbed environments, using appropriate technology;

Specific Expectation - B2.1: Students will use appropriate terminology relating to the environmental impact of human activity, including, but not limited to: carbon footprint, carbon neutral, and sustainability

Overall Expectation - B3: Students will demonstrate an understanding of some of the ways in which human activities affect the environment and how the impact of those activities is measured and monitored.

Specific Expectation - B3.4: Students will explain the concept of a “carbon footprint” and how it is used to measure the impact on the environment of a range of human activities

Strand D: Energy Conservation

Overall Expectation - D1: Students will evaluate initiatives and technological innovations related to energy consumption and conservation, and assess their impact on personal lifestyles, social attitudes, and the environment;

Specific Expectation - D1.2: Students will evaluate, on the basis of research, some of the advantages or disadvantages of technological innovations that contribute to the production of renewable energy and/or aid in conservation

Overall Expectation - D2: Students will investigate methods of saving energy & improving energy efficiency;

Specific Expectation - D2.1: Students will use appropriate terminology related to energy conservation and consumption

Specific Expectation - D2.2: Students will determine the energy consumption of their household over a given time period by reading and interpreting gas and/or electric meters, calculate the cost of consumption and suggest ways in which the household could conserve energy

Specific Expectation - D2.3: Students will use a research or inquiry process to compare the efficiency of different types or brands of a common household appliance brands or of audio-visual equipment and report their findings

***Note - The expectations below are not explicitly covered by the project but would be covered prior to or during the project as students would need some background knowledge of energy production, renewable & non-renewable sources of energy as well as energy conservation measures.

Overall Expectation - D3: Students will demonstrate an understanding of the basic principles of energy production, with reference to both renewable & non-renewable sources, & of methods of energy conservation.

Specific Expectation - D3.1: Students will explain the basic principles and characteristics of various types of power generation from nonrenewable sources and renewable sources

Specific Expectation - D3.2: Students will compare and contrast renewable and nonrenewable energy sources, using criteria such as availability, cost, and environmental impact

Specific Expectation - D3.3: Students will describe methods of energy conservation and some policies that are intended to manage energy demand in the home and the workplace

Specific Expectation - D3.4: Students will describe several criteria used in the construction of energy-efficient buildings

Key Concepts:

The key concepts learned include: alternative energy sources, energy conservation, energy consumption, carbon footprint of buildings and carbon emissions related to different energy sources.

Prior Skill Sets:

Students should be able to carry out some independent research or teacher-guided research and work in teams. They should also be familiar with different ways to present projects (e.g. PPT, models, etc.). Other than that, they do not need prior content knowledge except for the concepts related to the project that are already part of the course (e.g. greenhouse effect, global warming, climate change, renewable/non-renewable energy sources, etc.).

Materials and Equipment:

Computer lab or Chromebooks for research (some websites provided), handouts for energy use/consumption calculations for different energy sources, sample net-zero building designs, large piece of paper, play dough, toothpicks and other materials for building ‘model’ houses.

Safety:

No safety concerns

Timeline: Course summative task
4-6 weeks before the end of the semester with daily check-ins with students or every second day

- Hand out outline, discuss project and brainstorm ideas around ‘Is a net-zero building possible?’
- Provide websites that question the possibility to get them thinking
- Provide two periods per class for students to research the different features that make buildings more energy efficient

4 weeks before the end of the semester

- Ideas for initial design should be on paper/Google doc by now with reasoning
- They also have the option of working on a building template or a pre-existing building and modifying it to be more energy efficient
- Students should be getting an idea if net zero buildings are possible or not
- Teacher verifies features of building

3 weeks before the end of the semester

- They have started on their design
- They have a list of supporting sources

2 weeks before the end of the semester

- Students have submitted their last draft for comments by the teacher
- They have time to incorporate comments

1 week before the end of the semester

- Students do the gallery walk (2-3 days)
- Students answer questions about other designs and do peer evaluations

Last week

- Students have discussion about ‘Is a net-zero building possible?’ - debate/two corners style
- Exit interview that focuses in part on their design and the question

Instructional Planning and Delivery:

The inquiry focus is on students trying to figure out how to best achieve a net zero building or if it is even possible. They are not conducting experiments (as in more typical inquiry), but conducting teacher-guided research and have to do some basic calculations to be able to compare conventional to net-zero buildings, to design/redesign a net-zero building and to ultimately answer the question, ‘Is a net-zero building possible?’

Additional delivery notes:

In the past, we have included a field trip to LEED certified buildings such as the Algonquin College Construction Technology Centre or a few of the LEED homes in Ottawa (they offer open houses in the fall). We have also had speakers come to show sustainable building materials and to discuss LEED buildings.

Starting point:

Refer to the timeline above to determine how to best implement this activity in your SVN3E classroom. I found that doing it towards the end of the course as a culminating task worked well as, by then, students had some knowledge base to work from. Here is one way that I structure the course.

The theme of climate change or water, which links most of the units in this course, are good ones to use. I start the course with our impact on the planet so that students understand the necessity for measures such as net-zero or low-carbon buildings. For this part, I want them to become familiar with the concepts of the greenhouse effect, global warming and climate change as well as carbon footprint, carbon sources and sinks, among other key ideas. We also discuss the various ways that humans pollute the environment (discussions about climate change usually lead into pollution because students often think of carbon dioxide as a pollutant).

After the class explores the various ways in which humans pollute the planet, we look at how that pollution and global warming/climate change affects human health, although I have sometimes discussed our impacts on the environment and the consequent effects on our health together. For example, increased CO2 in the atmosphere from transportation power plants, industry, etc. leads to global warming, which leads to droughts, heat waves & changing pest (insect/disease) patterns, which, in turn, can lead to malnutrition/hunger in some parts of the world and heat stroke, disease and possibly death in others. Solutions are brainstormed and researched all along the way, which ties into waste management.

Natural resource management blends into climate change easily as well and we usually discuss this along with global warming (and its impacts on natural resources like water & forests) and pollution. Once students have an idea about the earth's natural resources and their uses, we go into energy although it's already come up earlier in discussing solutions to carbon emissions. We now revisit alternative energy sources from water, biomass, etc. It's around this point (about the end of November for semester 1 or end of April for semester 2) that I introduce the 'Is a net-zero building possible?'

Guiding questions

How much do current buildings consume in terms of energy?

Where in the building does this energy use come from (e.g. heating, cooling, appliances, water heating, etc.)?

How is this energy consumption measured? (kwh)

What are the carbon emissions associated with different types of energy? (how is this measured?)

Is it possible to power a building with alternative energy sources?

What are the different possibilities for renewable energy sources for buildings? Are they being used already?

How do conventional buildings compare to efficient/net-zero buildings?

What does net-zero mean? Why is net-zero a good goal to achieve?

Is a net-zero building possible or can we, at the very least, reduce our carbon footprint?

Goals for students:

- The primary goal is to come up with an approximate energy use of a regular building (e.g. house) and to see what changes could be made to bring it to zero (e.g. installation of solar hot water heaters, solar panels, high R-value insulation, high energy efficient windows and doors, etc.)
- To appreciate the interest/need in reducing the carbon footprint of buildings and to gain an understanding of the energy consumption of buildings
- To understand and be able to compare to some extent different energy sources for buildings, both renewable and non-renewable
- To gain an understanding of energy conservation measures that they can implement themselves in a building or their home

Getting them there:

The course--SVN3E--as it is being taught has all the pieces and big ideas that students need (see Section: Starting point above) to start on this project. The inquiry project can be done towards the end of the course (one month or so prior to the end; this is how I have done it) as this allows students to gain a good understanding of energy sources, energy conservation, resources in general, the carbon footprint of humans, etc. by that time. Most importantly, by the time we finish discussing the impacts that humans have/have had on the planet, students have a sense of why measures such as low-carbon or net-zero buildings are desirable.

The inquiry project:

Here (https://docs.google.com/document/d/1unKYa2Tk6TsBKYkSYRbq4Sg_pAApsNB2JtW_s017Uvk/edit?usp=sharing) is the link to the project outline

Students Support Resources

Introduction to net zero videos:

https://www.youtube.com/watch?v=FysJKq5yCfg (https://www.youtube.com/watch?v=FysJKq5yCfg)

https://www.youtube.com/watch?v=2oUZ4caZ3c0 (https://www.youtube.com/watch?v=2oUZ4caZ3c0)

https://www.youtube.com/watch?v=qAJIandP5c0 (https://www.youtube.com/watch?v=qAJIandP5c0)

Related Background Resources/Links:

https://www.buildinggreen.com/feature/problem-net-zero-buildings-and-case-net-zero-neighborhoods (https://www.buildinggreen.com/feature/problem-net-zero-buildings-and-case-net-zero-neighborhoods) and https://www.electric.coop/zero-net-energy-buildings-theyre-cracked/ (https://www.electric.coop/zero-net-energy-buildings-theyre-cracked/)

(starting documents with pros and cons to get students thinking if net zero buildings are possible)

Below are more websites for additional features and guidelines for net-zero buildings:

https://www.wbdg.org/resources/net-zero-energy-buildings (https://www.wbdg.org/resources/net-zero-energy-buildings)

http://www.hme.ca/reports/The_Challenges_of_Designing_and_Building_a_NetZero_Energy_Home_in_a_Cold_High-Latitude_Climate.pdf (http://www.hme.ca/reports/The_Challenges_of_Designing_and_Building_a_NetZero_Energy_Home_in_a_Cold_High-Latitude_Climate.pdf)

https://living-future.org/net-zero/ (https://living-future.org/net-zero/) (case studies when you scroll down)

https://www.cbc.ca/news/canada/ottawa/net-zero-homes-ontario-climate-change-1.3637515 (https://www.cbc.ca/news/canada/ottawa/net-zero-homes-ontario-climate-change-1.3637515)

Assessment Opportunities are here (https://docs.google.com/document/d/1unKYa2Tk6TsBKYkSYRbq4Sg_pAApsNB2JtW_s017Uvk/edit?usp=sharing) and include:

(1) a research summary of average carbon footprints of buildings and net-zero building features

(2) a building design that includes energy efficient features and could be net-zero

(3) gallery walk and observation

(4) summary of other designs

Future Opportunities/Extensions:

1. Debate on net zero buildings - possible or not?
2. What could be done at the students' school to improve energy efficiency or to move to net zero?
3. How could students' homes/apartments be more energy efficient?
4. How do energy efficient buildings also provide a healthy living/working environment?
5. Can water conservation in a building also help with its energy consumption?
6. What about sustainable/locally-sourced building materials - does this factor into energy efficiency?

WATCH THE VIDEO
02:59 min

(//www.youtube.com/embed/hEQGkQhQhl0?width=800&height=450&iframe=true)

RESOURCES

- Canadian net zero homes (https://www.youtube.com/watch)
- Introduction to net zero (https://www.youtube.com/watch)
- An overview flowchart of the inquiry project (https://connex.stao.ca/sites/default/files/svn3e_net_zero_overview.pdf)

ELEMENT

- Inquiry (/expert-elements/inquiry)

(/classroom-catalysts) **RETURN TO CATALYSTS (/classroom-catalysts)**