CEISMC
Georgia Tech Center for Education Integrating Science, Mathematics, and Computing

in partnership with The Kendeda Building for Innovative Sustainable Design

Lesson: Sustainably Solar

Unit Introduction

Grade Level/Band: 8

Summary

The Living Building Challenge (LBC) is the world's most ambitious and holistic green building achievement. Rather than being less bad for the environment and people, Living Buildings foster regenerative systems. This not only includes a relationship between humans and nature where we give back more than we take, but also restorative relationships amongst people themselves. Regenerative buildings are designed to not just conserve resources but have a positive impact on their environment. For example - they may create and store energy for the community or clean storm water runoff.

Flowers are a metaphor for regenerative buildings. Flowers receive everything they need from their environment, leaving nothing behind except for seeds. Therefore fully certified LBC projects must meet all of the objectives contained in these seven performance areas or "Petals": Petals are Place, Water, Energy, Health and Happiness, Materials, Equity, and Beauty. Moreover, the project must prove that it is net-positive for water and energy over a minimum of 12 months of continuous occupancy and operations. The seven

The Kendeda Building for Innovative Sustainable Design on Georgia Tech's Atlanta campus is the first building in Georgia and 28th in the world to earn LBC certification. This achievement symbolizes Georgia Tech's commitment to create a one of a kind, holistic green building that will hopefully result in additional examples of regenerative built environments in our region.

Here are some examples of The Kendeda Building's features that foster regeneration:

- The building is net-positive water. It manages rainfall onsite, thereby virtually eliminating stormwater runoff during normal rain events, treats greywater in a constructed wetland, and composts human poo and pee onsite.
- By incorporating salvaged materials during construction, the building diverted more waste from the landfill than it sent.
- To keep economic benefits local, at least 50 percent of the building materials and services were sourced from within 1,000 kilometers (621 miles) of the site. The building also prioritizes occupant health and happiness.

The building is composed of materials screened for common hazardous chemicals known to harm human and environmental health.

CEISMC
Georgia Tech Center for Education Integrating Science, Mathematics, and Computing

in partnership with The Kendeda Building for Innovative Sustainable Design

A core requirement of the LBC is that a Living Building must over the course of a year generate more electricity than it uses (at least 105%), thereby making the building net-positive energy. The electricity has to be generated onsite from renewable sources such as wind or solar energy.

At the Kendeda Building, solar power generated via photovoltaic (PV) panels supplies the building with approximately 200% of its annual energy needs.

This eighth-grade lesson focuses on the following Living Building Challenge Petals :

- Energy,
- Health and Happiness,
- Beauty
- Equity

Students will explore physical science topics of energy and energy transformations through online simulations and exercises. They will investigate renewable and nonrenewable energy sources and will connect these sources to sustainable practices in the Living Building. Students will then collaborate to create a mini-Living Building powered by solar energy to highlight the above petals.

CEISMC
Georgia Tech Center for Education Integrating Science, Mathematics, and Computing

in partnership with The Kendeda Building for Innovative Sustainable Design

Background and Preparation

Background Knowledge

Students should have the basic knowledge of matter and energy including an understanding of the law of conservation of matter. Students should understand energy transformations as demonstrated in food webs. Students should have an understanding of the sun's role in processes such as heating land and water.

At the end of this lesson, students:

- Will be able to state the law of conservation of energy.
- Will understand the importance of energy conservation
- Will be able to compare and contrast renewable and non-renewable sources of energy.
- Will be able to create a mini-Living Building that showcases one or more petals of the Living Building Challenge
- Will be able to communicate the significance of the Kendeda Building on Georgia Tech's campus as a model for sustainability and equity

Time Required:

This lesson is designed to be completed in **eight class periods (assuming 50 minute class sessions**). More or less time can be added depending on the complexity of final projects.

Key Vocabulary

- **Energy**: ability to do work
- **Law of Conservation of Energy**: states that energy cannot be created nor destroyed, but it can change form
- **Electricity** : flow of electrons in a current, flow of electrical power or charge
- **Nuclear Energy** : energy contained in atomic nuclei (released by splitting atoms)
- **Chemical Energy**: Energy stored in chemical bonds
- **Photovoltaic**: device that transforms radiant energy directly into electrical energy
- **Radiant Energy**: energy carried by an electromagnetic wave
- **Thermal Energy**: the sum of kinetic and potential energy of the particles in a material
- **Conductor**: materials in which electrons can can move or transfers heat easily
- **Inexhaustible**: Unable to be used up, existing in abundance
- **Sustainable:** Conserving an ecological balance by avoiding a depletion of natural resources.
- **Equity**: the quality of being fair and just - equity means recognizing that we do not all start from the same place and must acknowledge and make adjustments to imbalances.
- **Renewable Energy**: energy derived from natural sources that are replenished at a higher rate than they are consumed
- **Non-Renewable**: comes from sources that will run out or will not be replenished in our lifetimes

CEISMC
Georgia Tech Center for Education Integrating Science, Mathematics, and Computing

in partnership with The Kendeda Building for Innovative Sustainable Design

Preparation

Materials and Supplies

- Computers/Tablets/laptops,
- Nearpod subscription (free)
- Small shoe box
- LED lights,
- paint, glue/tape, scissors, markers,
- Legos,
- dry erase board or scratch paper
- copper tape,
- mini solar panels,
- flashlight

Optional: beans

Websites: www.eia.gov and livingbuilding.gatech.edu/

Standards

Next Generation Science Standards	**MS-PS3-3.** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]
Georgia Standards of Excellence	**S8P2.** Obtain, evaluate, and communicate information about the law of conservation of energy to develop arguments that energy can transform from one form to another within a system. • **c.** Construct an argument to support a claim about the type of energy transformations within a system [e.g., lighting a match (light to heat), turning on a light (electrical to light)].
Essential Questions	• What is energy? • How is it transferred and conserved between objects in a system? • What is meant by conservation of energy? • If energy is conserved, why do people say it is produced or used?

Implementation

Engage

Students will watch a video introducing the Earth's biomes. Students will participate in a group discussion of the video and focus on challenges associated with survival in each particular biome.

Explore

- In teams, students will research biomes and learn about their basic characteristics, location, and organisms. The teams will research different organisms and their adaptations to the biomes. These organisms will be applied for learning goals later in the unit.
- Students will learn about the Living Building Challenge and, as a class, break down the problems of producing net-positive water, net-positive energy, and sustainable materials. Students will learn what Bio-Inspired design is with a video and activity.
- Students will engage in a gradual release lesson on bio-inspired design. Students will observe how the teacher researches an organism to discover the mechanism behind the adaptation and how to apply it to a challenge of the Living Building. Then students and teacher will work on an example together, and finally, students will use previous biome research and additional sources and apply their knowledge to the challenges of the Living Building. Groups will choose one challenge to address (such as water filtration, pumping water, cooling the building, etc) and apply their knowledge of organism adaptations to design a Bio-Inspired Design Solution to the challenge.

CEISMC
Georgia Tech Center for Education Integrating Science, Mathematics, and Computing

in partnership with The Kendeda Building for Innovative Sustainable Design

5E Lesson Overview

Engage

Students will build off of their initial ideas of forms and types of energy to explain how energy transfers form. Students watch the Introductory video and complete lab.

Explore

Students will explore and research about different types of energy. Students will research examples of both renewable and non-renewable forms of energy. Students will be introduced to solar energy as an alternative to fossil fuels.

Explain

Students will engage in an exploratory activity that encourages the analysis of energy use in homes and businesses across the United States. Students will examine how they use energy and start to think about alternative sources of energy.

Extend

Students will explore a sustainable, regenerative building at Georgia Tech, the only of its kind in the southeast: The Kendeda Building for Innovative Sustainable Design . This building gives back more than it takes. Using solar energy and electrification, the long term goal of the building is to serve as a living facility for generations of students to come.

Evaluate

The goal of this phase is for students to pull information from prior activities to design a mini living building that satisfies four of the seven petals (one of the petals must be energy) of the Living Building Challenge. Formative assessments are embedded throughout the explore tier to include quizzes and open responses. The teacher will evaluate student response and aid students in developing their own understanding. During this phase students will be evaluated on their final design.

CEISMC
Georgia Tech Center for Education Integrating Science, Mathematics, and Computing

in partnership with The Kendeda Building for Innovative Sustainable Design

Engage

Phenomenon Observation

This is an introduction to the photovoltaic effect. The teacher will do a short demonstration lab and then show a short introduction video to further engage students in conversations about energy. Students will work to complete a quick write and share and then complete the energy anticipation guide.

Materials Needed

- Laptops/tablets
- Battery powered flashlight
- Photoelectric PhET Lab worksheets
- Energy Anticipation Guide

Time Frame

2 to 3- fifty minute class periods depending on how quickly students are able to complete the lab.

Teacher Prep

Have videos ready to play before students arrive. Students will need printed worksheets or access to computer to complete them digitally.

Procedure

1. Have the students complete left column of the Energy Anticipation guide - (https://bit.ly/EAG8lp). They can work in groups or individually to answer the questions. Once they have has a chance to answer each question you can review the different answers and have a class discussion.
2. List key vocabulary terms on the board so students can reference them later.

   - **Electrons**: A small particle with a negative charge that is found in all atoms.
   - **Photons**: a tiny particle that comprises waves of electromagnetic radiation.
   - **Energy:** ability to do work
   - **Photovoltaic effect**: It is a physical and chemical phenomenon. Photovoltaic effect is the generation of voltage and electric current in a material upon exposure to light. This phenomena enables solar energy use.
   - **Electricity**: flow of electrons in a current, flow of electrical power or charge

Procedure (continued)

3. Run Teacher Demo: The teachers will hold up a battery powered flashlight turning it off and on. Ask students to discuss and identify the process of turning on a flashlight. (chemical potential -> electrical -> mechanical -> thermal -> radiant). If they can't name them all that's okay. The goal is to get them thinking. You can provide students with other examples such as charging a cell phone/ computer or riding a scooter/riding a bus.
4. After discussion students watch the Introductory video(s):Einstein: The Photoelectric Effect: https://bit.ly/photovideo8lp
5. Working in groups or individually have students complete the Photoelectric PhET lab - https://bit.ly/Phetlab8lp
6. Once students have completed the lab have them complete the right column Energy Anticipation guide (https://bit.ly/EAG8lp) and see if their views on energy have changed. Lead a short discussion to see where student views have changed. Ask students why their views have changed.

CEISMC
Georgia Tech Center for Education Integrating Science, Mathematics, and Computing

in partnership with The Kendeda Building for Innovative Sustainable Design

Explore

Energy Research

Students will explore and research about different types of energy. Students will research examples of both renewable and non-renewable forms of energy. Additionally, students will be introduced to solar energy as an alternative to fossil fuels.

Materials Needed

- Computers/Tablets/laptops
- Near-pod Activities (energy/solar energy)
- Energy: https://bit.ly/Nearpod-Energy8lp
- Solar Energy: https://bit.ly/nearpod-solar8lp

Time Frame

Two 50-minute class periods

Teacher Prep

Have Nearpod activity ready.

Procedure

1. Students will complete the Energy (https://bit.ly/Nearpod-Energy8lp) and Solar Energy (https://bit.ly/nearpod-solar8lp) nearpod activities to be able to identify sources of renewable and nonrenewable energy and to identify solar energy as an inexhaustible resource.
2. The students will take a quiz at the end of the nearpod assess learning. Nearpod Activity (https://bit.ly/Nearpod-Energy8lp)

CEISMC
Georgia Tech Center for Education Integrating Science, Mathematics, and Computing

in partnership with The Kendeda Building for Innovative Sustainable Design

Explain/Explore

Daily Energy Use

Students will engage in an exploratory activity that encourages the analysis of energy use in homes and businesses across the United States. Students will examine how they use energy and start to think about alternative sources of energy. Students will also be able to understand the dependence that societies (and their own dependence) have towards fossil fuels . Students will be able to illustrate the long-lasting impact of the use of fossil fuels to produce energy.

Materials Needed

- Print this handout for students: https://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/GA.pdf
- Print Georgia energy consumption. https://www.eia.gov/state/?sid=GA#tabs-1

Time Frame

One to two 50-minute class period

Teacher Prep

Have hands outs and links ready to share.

Procedure

1. Share this statement with students: Per household electricity consumption in Georgia** is among the highest in the country. (www.eia.gov) Ask students why they think Georgia may have some of the highest electricity/energy use in the country.
   a. Print this handout for students: https://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/GA.pdf
   b. Have students work in small groups to examine how residents in Georgia use energy and why their rates are high. Ask students to develop a hypothesis.
2. Look at Georgia's Energy Consumption by type of energy** : https://www.eia.gov/state/?sid=GA#tabs-1
   a. Ask students if this matches your class energy use chart.
   b. Identify the renewable energy types
3. Have students now brainstorm their own energy consumption in their daily lives (home, school, car, bus etc). Write all the uses of energy on your front board. Then have students identify the sources of the energy used. Most of their uses of energy will be powered by fossil fuels. This is a good activity to have students realize their dependence on fossil fuels and start to think about alternatives

Procedure (continued)

to how they power their lives.

4. Challenge students to think about if they use any renewable energy sources in their daily lives. Calculate the percent of the different types of energy consumed by the class.

Examples

- Bus to school - diesel gas (FossilFuels)
- Heat in home (Natural Gas (Fossil Fuels)
- Lights in classrooms - Electricity (Powerplant - fossil fuels)

5. After reviewing student energy use- Ask student to think about how using non-renewable resources can affect our energy use in the future.

Additional Resources

- https://www3.uwsp.edu/cnr-ap/KEEP/Documents/Activities/School%20Building/ClassroomEnergyFlow.pdf
- Article and Question Set: (https://bit.ly/art8lp) How the United States uses energy.
- Renewables Activity*: https://bit.ly/LB8renewables (Adapted from R.E.A.C.T- Education Office at the National Renewable Energy Laboratory)
  - *This is a simulation activity using beans to predict what would happen if we don't pivot to more renewable energy sources.*
  - *This activity requires a free teacher account. Make sure to check the links.*

Closing/Exit Ticket Prompts for Students:

- Societies do need/do not need fossil fuels because…
- Based on evidence from the lesson, why do you think societies need fossil fuels and how does it have long-lasting consequences?
- What are some ways we can reduce our dependence on fossil fuels?

**The EIA.gov (US Energy Administration) website has energy data for every state. If your class is located in another state, go to the EIA homepage and search under geography for your state's information.

CEISMC
Georgia Tech Center for Education Integrating Science, Mathematics, and Computing

in partnership with The Kendeda Building for Innovative Sustainable Design

Extend

Students will explore a sustainable, regenerative building at Georgia Tech, the only of its kind in the southeast: The Kendeda Building for Innovative Sustainable Design . This building gives back more than it takes. Using solar energy and electrification, the long term goal of the building is to serve as a living facility for generations of students to come.

Materials Needed

- Laptops/tablets
- Worksheets: KWLO Chart Handout

Time Frame

Two 50-minute class period

Teacher Prep

Day 1

- Display this quote on your board: "**Being sustainable is no longer about doing less harm. It's about doing more good**." - Jochen Zeitz
- Set up the video What are Petals? https://www.youtube.com/watch?v=PSL93ltQxzg
- Print a copies of the Explore Petal diagram and KWLQ chart: https://bit.ly/LBKWLQ

Day 2

- Set up "Good Video" - https://www.youtube.com/watch?v=UTrgdcHJC3c
- Set up Energy Petal video - https://livingbuilding.gatech.edu/energy-petal
- Print Living Building Sources of Energy worksheets

CEISMC
Georgia Tech Center for Education Integrating Science, Mathematics, and Computing

in partnership with The Kendeda Building for Innovative Sustainable Design

Procedure

Day 1

1. Ask students to think about the meaning of the quote on the board – both what it means to their personal lives/habits and society. Have students reflect on the quote and then conduct a class share.
2. Think- Pair-Share: Show video : What are Petals? and Explore Petal diagram (https://bit.ly/petals8lp) Students should review the diagram and discuss the meaning of each petal with a partner.
3. Have each pair should choose one or two petals that call out to them and share why they chose that petal. Students should relate the petals back to the introductory quote and explain how the petals encourage people "to do more good."

Students then work in a pair and fill out the "Know" and "Want to Know" columns of a KWLQ chart: https://bit.ly/LBKWLQ for their chosen petals.fs Think about the statistic that we learned in the prior

Day 2

1. Have students navigate to the Living Building Website: https://livingbuilding.gatech.edu/
   a. Click on Living Building Challenge
   b. Show the "Good Video" - https://www.youtube.com/watch?v=UTrgdcHJC3c
   c. Use the two petals that your pair chose in the prior activity and click on the webpage for the petals. Fill in the "Learn" and "Questions" column for each petal. Watch any videos in the section.
2. Tell students that as a class, they will also focus on the energy petal to examine how a sustainable building can produce energy without burning fossil fuels. Teachers should show the video from the Energy Petal https://livingbuilding.gatech.edu/energy-petal and create a class list brainstorming all the ways the Kendeda Building produces energy without using fossil fuels.
3. After brainstorming this list, start to label the types and forms of energy listed - Renewable, Nonrenewable, Solar, Radiant, Thermal etc. Use this document to describe the different types of energy produced/used in the Living Building.

Closing/Exit Ticket

Think about the statistic that we learned in the prior lesson: **Per household electricity consumption in Georgia** is among the highest in the country.** Why do you think that constructing a living building in Georgia is so important? What are some challenges to constructing the building in Georgia? How can some of the practices in the petals extend to your household?

CEISMC
Georgia Tech Center for Education Integrating Science, Mathematics, and Computing

in partnership with The Kendeda Building for Innovative Sustainable Design

Evaluate

Living Building Challenge

The goal of this phase is for students to pull information from prior activities to design a mini living building that satisfies four of the seven petals (one of the petals must be energy) of the **Living Building Challenge**. Formative assessments are embedded throughout the explore tier to include quizzes and open responses. The teacher will evaluate student response and aid students in developing their own understanding. During this phase students will be evaluated on their final design.

Materials Needed

- Living Community Project
- Recommended materials: newspaper, card stock, cardboard, foam board, wood, shoeboxes, etc.(Think insulation)
- Copper tape, LED lights, copper wire, solar panels, small fans and motors
- Alternative wiring may include insulated wire, holiday lights, brads, project lights, and paperclips.
- Switches can be used in the build but are not required.

Time Frame

One to two 50-minute class period

Teacher Prep

It's time for your students to construct their building….have them start thinking about the design with this question: "What if every single act of design and construction made the world a better place? How can we apply the "doing good" principle of sustainability to building design? Create a class list of ways buildings can "do good" and how architects and engineers can make the world a better place. Use the activity on pages 6 & 7 of the 5th Grade Lesson "Are you Plugged In?" as your guide.

Procedure

1. Design and construct a "Living Building" for your community that satisfies at least 4 of the Living Petals and runs off of Solar Energy. Living Community Project.docx
2. The solar panel must work to power at least one room(lightbulb) in your building.
3. You may work with a partner to make a shoe box sized house wired with series or parallel circuits powered by the sun.
4. Students will present their projects to the class.

Closing

Which petal was most difficult to incorporate in your project? Why? Did this change throughout the design process?