ENERGY AND CLIMATE CHANGE
PATHWAYS TO SUSTAINABILITY
High School Grades 9-12

http://goo.gl/higXGJ
# Energy and Climate Change: Pathways to Sustainability

High School Grades 9-12 – Eco-Schools USA

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## LESSON 1: A GREEN REVOLUTION

An Introduction to Eco-Schools USA

Knowing that solutions and mitigation to our energy needs are crucial to battling our long term environmental and societal challenges, it is our hope that the Eco-Schools program will strengthen school’s commitment to sustainability in which eventually sustainability becomes a part of the internal and external culture of the school.

## LESSON 2: LIGHTS, CAMERA, ACTION

Conducting and Energy Audit

The nation’s school districts spend more than $7.5 billion a year on energy. Schools are the largest energy consumer in many municipalities. But up to 30 percent of that energy is used inefficiently or unnecessarily. Students dive into the audit process by assessing their school’s energy efficiency. Actively engaged, students will collect and analyze data, and develop action plans in an effort to raise energy awareness and reduce carbon emissions.
LESSON 3: THIS BLANKET IS MAKING ME HOT
Green House Gas Investigation........................................................................................................3-1
Some greenhouse gases occur naturally and are released into the atmosphere through natural processes and
human activities and others are strictly created and released through human activity. Students will learn
exactly what are greenhouse gases, their significance in the atmosphere, and the role they play in energy and
climate change.

LESSON 4: WHY ALL THE WIGGLING ON THE WAY UP?
Investigating CO$_2$ Trends......................................................................................................................4-1
The Earth has an average albedo, which describes how much sunlight is reflected on average for the whole
planet and the whole year. How fast the planet warms in response to adding greenhouse gases to the
atmosphere depends in part on climate feedbacks. Students will collect ice-snow data and make connections
to trends in albedo. What could be the causes for current trends and what role both seasonal and human
induced activity play.

LESSON 5: WHEREFORE ART THOU, ALBEDO?
Ice-Albedo Feedback..............................................................................................................................5-1
The Earth has an average albedo, which describes how much sunlight is reflected on average for the whole
planet and the whole year. How fast the planet warms in response to adding greenhouse gases to the
atmosphere depends in part on climate feedbacks. Students will collect ice-snow data and make connections
to trends in albedo. What could be the causes for current trends and what role both seasonal and human
induced activity play.

LESSON 6: NATURALLY SPEAKING
Investigating Natural Resource Production in My State.............................................................................6-1
Our energy needs have been met in many ways throughout history, from fire rings and wood burning hearth’s,
to oil burning lamps and steam powered engines. Students will learn how different parts of our society use
energy and how that energy use has changed over time. Next students will investigate natural resources
found in their state and the fuel mix used to satisfy the state’s energy needs.

LESSON 7: STIFLING, OPPRESSIVE, SWELTERING, OH MY!
The Science behind Heat Waves and their Effect on Human Health................................................................7-1
In August 2007, a severe heat wave affected much of the central, southeast, and eastern parts of the United
States. This lesson will give students an opportunity to explore how the heat wave progressed and learn about
the impacts on human health. Students will collect air temperature and longwave radiation data and look for
connections to ground level ozone allowing them to analyze and draw conclusions about the effects of heat
waves on various populations.

LESSON 10: MASTER P IN THE HOUSE
An Energy and Climate Change Action Plan..............................................................................................8-1
The United States is home to just five percent of the world’s population but consumes more than twenty
percent of its energy. Students will take data collected from Lesson 2 along with new knowledge gained
regarding energy and climate change and develop a class, grade level, or hopefully a school-wide
improvement plan. This plan will be monitored and evaluated for effectiveness and will reduce the
environmental footprint of the school.
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I. An Introduction to Eco-Schools USA

A part of an international family, Eco-Schools is found in over 50 countries, serving 50,000 schools and over 12 million students every year. National Wildlife Federation is privileged to have been selected as the sole US host for the Eco-Schools program which we rolled out in the fall of 2009. To date there are over 3200 registered Eco-Schools in the US. There are three important components to the Eco-Schools USA program – the Seven Step Framework, the Pathways to Sustainability, and our awards system. The problem-based Seven Step Framework is universal and guides schools as they develop, plan, implement, monitor, and evaluate their sustainable initiatives. As a part of this process, students choose pathways, (areas of focus) which help them increase their sustainable practices at school and in the greater school community. After successful implementation of the framework and their selected pathways, students may apply for a Bronze, Silver, and/or the ultimate recognition, the Green Flag. (It is important to note that in order to attain the Silver or Green Flag awards, schools must complete the energy pathway.)

National Wildlife Federation and its Eco-Schools USA program believe educators play a key role in developing an energy and climate literate citizenry. Energy and climate change are two of the most significant environmental issues of our time and therefore are two of our environmental focus areas or pathways with our Eco-Schools USA program. Starting at a young age, students begin to develop their understanding of the Earth system and the role natural and human activity play in that system. Now, more than ever it is critical that students are taught about the past, present, and future of energy and climate change as they will be the future decision makers in an economy and market starving for scientists, engineers, and mathematicians. We hope the Eco-Schools program will provide opportunities for students to be exposed to “real science” that is not only experiential and engaging, but understood and applied. Providing them with the ability to communicate about energy and climate change will afford future generations to make informed decisions as well as neighborhood and community changing actions. It is our desire that educators utilize this curriculum to attract and retain students in STEM disciplines as they relate to energy and climate change, and inspire the next generation of Earth system scientists.

The National Wildlife Federation has a 40-year history of developing and delivering high quality educational programming focused on the use of nature, the earth and wildlife study and observation to advance science learning and non-fiction, informational reading. Our programs currently serve about five million children and students each year. NWF is particularly well-suited to develop and deliver an age-adapted curriculum on climate and energy, having recently developed and published the accepted U.S. national standards for effective climate change education for 4th, 8th and 12th graders. These national education guidelines have been officially endorsed and adopted by the North American Association for Environmental Education as effective climate- and energy-related education tools. They are specifically designed in keeping with the Association’s broader national guidelines for excellence in environmental education. The NWF/NAAEE guidelines for age-appropriate, 4th grade through high school, climate change education are available to educators for free at:

Students at Acton-Boxborough Regional High School spearhead an effort to save energy and green their campus -

In September 2010 Kate Crosby, Energy Advisor for the Acton-Boxborough Regional School District, brought together a group of students at the local high school who were interested in understanding energy conservation. On several Saturday mornings, Kate and the students walked through the school and used Kill-a-Watt meters to assess energy use in the building. Their goal was to gather basic information about how much electricity was being used by plug-in devices in the school, data that no one in the district had at that time. Based on the data, students spent the rest of the school year creating a Power Down Project aimed at reducing energy use at Acton-Boxborough Regional High School. Inspiration for the project came directly from the team’s determination to embrace energy conservation. During the initial investigation of energy use at the school, one student sent Kate an email saying that she could not stop thinking about energy conservation and wanted to get serious about it. Another student spoke to Kate about a light that was bothering her because it was always on and had no apparent off switch. Still other students drew attention to a computer lab that was running 24/7. Together the students gained awareness and initiated several projects under the banner of the Power Down Project, including:

**Power Down Fridays** – Students designed and made colorful door tags to hang on classroom and office doors to remind staff to power down equipment on Friday afternoons. In addition, students wrote emails that went out to all staff, created posters and contributed morning announcements to help promote powering down on Fridays.

**Classroom Audits** – Students did weekend audits of every classroom and office and left hand-written notes for teachers and staff with tips and advice for reducing their energy consumption. These audits were conducted three times over the school year, with steady improvement in the number of rooms that were successfully powered down.

**Light Bulb Exchange** – Students set up a table in the lobby of the school and for two days gave out energy-saving compact fluorescent light bulbs in exchange for incandescent bulbs currently in use at the school. The students worked with teachers and staff to exchange 110 light bulbs, which resulted in $1,000 a year in energy savings.
By the end of the school year, electricity consumption at the school was down by 5.5% which resulted in a savings of $33,000 for the school. The school’s ability to save this much money through energy conservation garnered a phenomenal response from faculty and staff for a campaign powered by students.

In the spring of 2011, one of the student leaders of the group spoke with Kate and expressed her desire to tie together all of the clubs and projects going on around the school that had to do with the environment. Kate was interested in connecting the Power Down Project with a network of other schools working on similar issues. So the team researched green school programs and came across the Eco-Schools USA program. They felt it was a really good fit, and found the international component of the program, including the ability to connect with schools in other countries, very appealing. To connect globally go to: http://ecoschools.org/connect/

Thirty-eight people attended the Green Council’s first meeting. Twenty-two of the attendees were students; the rest of the meeting was made up of community members and school staff. So far this year, the Green Council has been working on implementing the Eco-Schools USA audit and developing their action plans. Ultimately they are looking to apply for a Green Flag award through the Eco-Schools USA program this spring!

Update: They received their Green Flag in the spring of 2013!

To learn more about Acton-Boxborough Regional High School’s sustainability efforts: https://sites.google.com/a/abschools.org/sustainabilityabrhs/home

To read Kate Crosby’s guest blog on NWF’s Wildlife Promise where she highlights the school’s very successful (and fun) trash audit party: http://blog.nwf.org/2011/12/guest-post-eye-on-the-green-flag-massachusetts-eco-school-holds-a-trash-audit-party/

II. SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH
What’s Going Green Have to Do with It?

Living in the digital age we have the world at our fingertips, a virtual expanse of worlds that are only limited by our imagination. Over time, education has tried to stay in step with the latest trends, best practices, and educational research, however, in moving forward we have forgotten critical components related to educating our students and in the process have fallen behind and no longer lead the world in the areas of math and science. As our nation’s schools work tirelessly to mitigate this loss with limited budgets, they look to the community to provide outstanding opportunities and support for their science, technology, engineering, and math (STEM) initiatives. Therefore, school districts partner with only the best in the field to provide a variety of experiential learning opportunities for their number one priority – their students. Eco-Schools USA is one such partner, a partner who helps to strengthen the STEM initiatives of the Houston Independent School District.
Eco-Schools USA takes a holistic approach to sustainability within the school building, outside the school building, and within the greater school community. Addressing sustainability on campus isn’t just about recycling and turning off the lights; it’s about providing students with the tools, opportunities, and time to create and solve environmental issues in their communities. **Students who participate in the Eco-Schools USA program use and practice skills important in STEM fields, such as critical thinking, problem solving, and collaboration that allow them to be creative and innovative.** These skills coupled with STEM content knowledge and practices make for dynamic learning experiences. For example –

**SCENARIO 1:** After completing and analyzing the Eco-Schools USA energy audit, students find that temperatures in the west facing rooms go up by more than two degrees throughout the afternoon even with blinds drawn. So students set out to determine solutions to this problem through research, design, and experimentation and decide they can look at several different variables to help decrease this rise in temperature. These variable include, a tree line to shade the west facing rooms, working with district facilities to test for air leaks in the window seals, installing solar awnings, and curtains. Students break into teams to further investigate the effectiveness of each variable through product testing, partnerships, and continued research. They also look into the cost for the project and its potential return on investment, ROI. After completing this students come back together and as a whole discuss their findings and make a final decision as to the best solution to the problem. From design and experimentation come questions: Can I create a sealant that will change color when a leak occurs? Can I use peel-and-stick solar panels on a refractory metal awning or solar shingles on a wooden awning as a sun block? How many kW can be produced from these awnings? What fabrics work best to absorb heat?

**SCENARIO 2:** Students want to increase the biodiversity at their school to support a pond for native macro and micro invertebrates and small aquatic species to better support various learning opportunities and to provide field experiences for the neighboring elementary schools. After completing the Eco-Schools USA biodiversity audit they work together to develop a plan with short, medium, and long term goals. These goals and learning experiences deal with landscape architecture, soil and water quality, invasive v. native plant and animal species, deciding upon the types of learning that will take place and designing the space accordingly, determining the permitting needed, conducting a cost analysis and many more. One feature they want to include is a bridge that spans the width of the pond so that students can better attain samples, provide other vantage points from which to make observations, and allow students to get from one side of the pond to the other safely. A team of students work to determine the design, shape, and type of material needed for this part of the project. They build several models based on their research and measurements, and test them for their ability to support weight whether it is evenly or unevenly distributed. After coming up with what they feel is a working design they collaborate with a local structural engineer to help support their findings.

Whether a student is in kindergarten or twelfth grade, they can be problem solvers and innovators; **students are born wonderers and makers,** no matter whether their innovation is 3D, virtual, written, and spoken, or a combination. The ability to communicate about one’s work or a group’s cooperative efforts is and will continue to be a critical skill necessary for success. Technology is an inherent part of science and engineering practices. Through web design, mathematical computation, animation, coding, research, writing, and more, students have the ability to effectively communicate through their technological savvy adding to the power of their work. The Eco-Schools USA program is just one way to engage student’s innate curiosity and love for the natural world through the lens of STEM. **Students are the creators of local solutions now, so that in the future they will have the knowledge, skills, and training when they are called upon to solve environmental problems that affect our nation and our globe.**
III. THE 5E MODEL
Best Practice Strategy for Lesson Implementation

Adapted from NASA’s 5E Overview: “The 5E instructional model”
http://www.nasa.gov/audience/foreducators/nasaeclips/5eteachingmodels/index.html

The 5E instructional model is a constructivist set of teaching stages that allow teachers to Engage, Explore, Explain, Extend, and Evaluate students. This model reflects best practices in student learning and can be utilized in any subject area.

Engage
During this first stage you want to capture student’s interest – similar to the hook of a book or the first line in a short story and get them personally involved in the lesson. Here students will make connections to prior knowledge as you lay the foundation for further learning.

Explore
Now that you have their attention it is time to allow them to explore the content or concept, thus building new learning based on their understanding. Acting as the facilitator, the teacher provides guidance as students work in groups sharing and communicating their common experiences. Emphasis is placed on questioning, data collection and analysis, as well as critical thinking.

Explain
The purpose for the explain stage is to provide students with an opportunity to communicate what they have learned so far and figure out what it means. Explain is the stage at which learners begin to communicate what they have learned. Language provides motivation for sequencing events into a logical format. Communication occurs between peers, with the facilitator, and through the reflective process.

Elaborate
This stage allows students to use their new knowledge and explore its implications. Students are now ready to elaborate upon this new learning and apply it new situations and other related concepts.

Evaluate
Evaluation serves both the teacher and the students as a tool to see how much learning and understanding has taken place. Evaluations can be both formative in nature, small snapshots along the way and summative, a culminating look at overall knowledge and understanding. Types of assessments include utilizing, rubrics, Thinking Maps®, Foldables®, teacher observations, student interviews, portfolios, and problem and project based learning products.

For more information regarding the 5E Model look to these resources.
The 5E Learning Cycle Model-MSU
http://faculty.mwsu.edu/west/maryann.coe/coe/inquire/inquiry.htm

The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications
http://bscs.org/bscs-5e-instructional-model
IV. ENERGY AND CLIMATE LITERACY FRAMEWORKS

Essential Principles and Fundamental Concepts for Energy Education and the Essential Principles for Climate Science

Energy: http://cleanet.org/clean/about/energy_awarenes.html
Climate: http://cleanet.org/cln/climateliteracy.html

The Energy Awareness and Climate Literacy Principles were created by the collaboration of many agencies including NASA, NOAA, US Forest Service, USGS, AAAS, NAAEE, US Department of Energy, and NRCL. These two documents serve several purposes but one of the most important is its development to serve educators who teach energy and climate science as a part of their curricula. Each guide is written to help you better understand the role that each play in our nation today.

These documents served to guide our writers in the development of the curriculum which is designed to increase the numbers of citizens who are energy aware and climate literate. As students become adults it is important that their decisions are based on learning that was accurate, free of bias, and responsible.

Energy Awareness Principles

Energy awareness is a complex topic. There are many ways to approach energy depending on the grade level, course topics, and instructional methods. Yet no matter the pedagogic setting, using a literacy based approach can provide a sound foundation to build learners’ understanding surrounding the topic. The energy awareness principles set out a broad framework from which to teach about energy topics. Energy is an inherent driving force throughout the universe and the Earth system. Humans use energy from various sources, and there are environmental, political, and social consequences related to our use of energy. Sustainable energy use can only occur when there is balance between the amount of energy available and the rate at which it is consumed.

- Energy drives the Earth system.
- The primary sources of energy used by society are non-renewable stores sources, such as fossil fuels and nuclear and renewable sources, such as solar, wind, hydro, and biomass.
- Humans’ use of energy has consequences on the environment that sustains them.
- The distribution of stored non-renewable and renewable energy sources varies around the planet, resulting in distribution and transmission costs.
- There are significant social, political, and equity issues associated with the human use of and access to energy.
- Developing a sustainable energy supply that minimizes impacts on the environment will require informed decision-making, technological and societal innovation, and improved efficiency.

CLEAN – Climate Literacy & Energy Awareness Network, June 2011.
http://cleanet.org/clean/literacy/energy.html
Climate Literate Citizens
Climate literacy is an ongoing process and is an understanding of your influence on climate and climate’s influence on you and society. A climate-literate person –

- understands the essential principles of Earth’s climate system,
- knows how to assess scientifically credible information about climate,
- communicates about climate and climate change in a meaningful way, and
- is able to make informed and responsible decisions with regard to actions that may affect climate.

The Seven Climate Literacy Principles

- The sun is the primary source of energy for Earth’s climate system.
- Climate is regulated by complex interactions among components of the Earth system.
- Life on Earth depends on, is shaped by, and affects climate.
- Climate varies over space and time through both natural and man-made processes.
- Our understanding of the climate system is improved through observations, theoretical studies, and modeling.
- Human activities are impacting the climate system.
- Climate change will have consequences for the Earth system and human lives.

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V. TIMELINE FOR IMPLEMENTATION
Moving From the Classroom to the Entire Campus

Full Year Model

October 1-November (Thanksgiving Break)
Implement the energy pathway on a small scale - a classroom, a pod of four rooms, or a hallway. This will allow you to manage your group(s), work out kinks, make connections to the curriculum and allow students to be creative.

December 1-February 1
With the many interruptions throughout the holiday season, use this time to work with your Eco-Action team on scaling the work they have done so far. What aspects can be implemented school-wide? What kind of support and permissions are needed? TIP: Start small and implement in stages.

February 3-7
Build excitement – talk it up – post on social media – morning announcements – posters – PTA – NJHS – StuCo – E-Newsletters, etc.

February 10-February 28
All school competition – Cool School Challenge or design your own

March 3-6
Energy Awards – some sort of celebration right before spring break for the teachers, classrooms, and students whose efforts made a difference.

One Semester Model

Second Week of January
Implement the energy pathway on a small scale - a classroom, a pod of four rooms, or a hallway. This will allow you to manage your group(s), work out kinks, make connections to the curriculum and allow students to be creative.

Third Week of February
Use this time to work with your Eco-Action team on scaling the work they have done so far. What aspects can be implemented school-wide? What kind of support and permissions are needed? TIP: Start small and implement in stages.

March 24-28 (week after spring break)
Build excitement – talk it up – post on social media – morning announcements – posters – PTA – StuCo – E-Newsletters, etc.

March 31-April 17
All school competition – Cool School Challenge or design your own

May 1-8
Energy Awards – some sort of celebration before school is out, for the teachers, classrooms, and students whose efforts made a difference.

These dates are flexible – the idea is to make it work for you. Testing starts up in April, and sometimes through May, however, the Eco-Action team may like to sponsor one final Energy hoorah after the testing season is over and before everyone leaves for the summer. You’re only limited by your imagination!!

These dates are flexible and only serve as a guide to help you in your planning. The idea is to make it work for you and your school. Testing starts up in April, and sometimes through May. You’re only limited by your imagination!!
VI. COOL SCHOOL CHALLENGE
Practical Strategies to Reduce CO₂ Emissions

Although the Cool Schools Challenge, (CSC), is not required there are many tools and resources within the challenge that will be of use to you as you address the Energy pathway. The CSC, is designed to be a competition between classrooms that promotes the reduction of carbon emissions over a set period of time. Students utilize the carbon calculator to evaluate progress and use it as a tool to show change over time and as a comparison against their competitors. The calculator is created in Excel and is downloaded at school so students can continually update their progress.

Schools who participate in the program will have completed the requirements to receive a Bronze award or if you have received your Bronze this will qualify you for a Silver and possibly a Green Flag.

The CSC is a large undertaking, whether you are doing the project between two classes or the entire school. Please spend time preparing, by reading the materials provided for you, free of charge, at http://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School/Cool-School-Challenge.aspx. The most important piece of advice related to the CSC that we can give you is that after you have read through the materials and you have a general plan/idea in your head, go to your building principal for support and then ask to engage your peers at the next faculty meeting or via email. Who knows...maybe your building administration of facilities department will offer up a sweet prize for the teacher and class who reduce their footprint the most!

What If I Can't Take On the Challenge Right Now?
If you feel the CSC is too much to take on at this time that's completely acceptable. However, the energy audit still requires you to utilize the carbon calculator found within the CSC materials. Remember the carbon calculator not only shows a reduction in CO₂, but also the cost savings from the efforts of the Eco-Action team. To receive the Silver or Green Flag award you must address energy, however, understand it’s not the size of your sample that makes or breaks your application, but that you are able to show a carbon footprint reduction based on the baseline data collected.

Do I Have To Have School Data from the Facilities Department?
No, however, check with your facilities department and see if they are able and willing to provide you with data that can help the Eco-Action team complete the audit thoroughly. For an example of a district wide and school specific “Energy Report Card” go to: http://www.aisd.net/AISD/Default.aspx?alias=www.aisd.net/aisd/energymanagement (Right side navigation under “Energy Reports”>“AISD Utility Report Cards”) This is a large file and starts with the district as a whole and then each school follows. It’s a great, easy to read visual!
READING EXTENSIONS
Summary Instructions

REQUIREMENTS
1. Using the Student Reading Resources or articles that you allow students to use related to the topic; write a summary meeting the following guidelines.
   a. Half to whole page
   b. Double spaced
   c. 12pt font size
   d. Times New Roman font

2. Do not print out the article. At the end of your summary write an endnote with the correct bibliographic information (http://www.easybib.com/) for your article.

DIRECTIONS
ARTICLE SUMMARY FORMAT

1. Name, date, class, and period

2. Paragraph #1-Introduction
   a. What is the title of the article (should be in quotes or italics)?
   b. Who is the author?
   c. What source or publication did the article come from?
   d. What is the date of the article?
   e. Write one to two sentences about what the article is about

3. Paragraph #2-Summary (Abstract) of Article
   a. Give a summary of the article; what is the article about?
   b. If necessary, you can write more than one paragraph summarizing the article

4. Paragraph #3- What did you think of the article (critique)
   a. Do you agree or disagree with the author(s)?
   b. Did it support or change your opinion of the topic; if not, why or if so, how?
   c. Did the writer demonstrate that he/she did sufficient research?
   d. What would you have added to enhance the article?

5. Paragraph #4-Conclusion
   What are your reasons for choosing your particular article and how does it relate to what we are studying now?
## Article Summary Rubric

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
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<tbody>
<tr>
<td>Requirements</td>
<td>All written requirements completed accurately and turned in on time.</td>
<td>4 of the 6 requirements were met.</td>
<td>3 of the 6 requirements were met.</td>
<td>Only 1 or 2 requirements met.</td>
</tr>
<tr>
<td>Spelling, Grammar, and Punctuation</td>
<td>There are no spelling, grammar, or punctuation errors in the summary. RUN SPELL CHECK BEFORE PRINTING!</td>
<td>There are no more than 2 spelling, grammar, or punctuation errors in the summary.</td>
<td>There are 3-4 spelling, grammar, and punctuation errors in the summary.</td>
<td>The summary has 5 or more spelling, grammar, and punctuation errors in the summary.</td>
</tr>
<tr>
<td>Summary of Article</td>
<td>The summary covers all the main points of the article.</td>
<td>The summary covers all but one of the main points of the article.</td>
<td>The summary covers all but 2 of the main points of the article.</td>
<td>The article is not well summarized. Most main points are missing.</td>
</tr>
<tr>
<td>Critique</td>
<td>All four questions under “Critique” are answered clearly and completely.</td>
<td>Three questions under “Critique” are answered clearly and completely.</td>
<td>Two questions under “Critique” are answered clearly and completely.</td>
<td>One or none of the questions under “Critique” are answered.</td>
</tr>
<tr>
<td>Overall Paragraph Construction</td>
<td>All paragraphs include introductory sentence, explanations or details, and concluding sentence.</td>
<td>Most paragraphs include introductory sentence, explanations or details, and concluding sentence.</td>
<td>Paragraphs included related information, but were typically not constructed well.</td>
<td>Paragraphing structure was not clear, and sentences were not typically related within the paragraphs.</td>
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<tr>
<th>Total Rubric Points</th>
<th>Grade Equivalent</th>
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</thead>
<tbody>
<tr>
<td>16-20</td>
<td>A</td>
</tr>
<tr>
<td>11-15</td>
<td>B</td>
</tr>
<tr>
<td>6-10</td>
<td>C</td>
</tr>
<tr>
<td>1-5</td>
<td>F</td>
</tr>
</tbody>
</table>

Self-Assessment: ___________ Grade Equivalent: ___________

Teacher Assessment: ___________ Grade Equivalent: ___________

Student and/or teacher comments:
How do I import data into an Excel spreadsheet?

1. Access data from My NASA Data:
   a. Once you have all the parameters set for your desired data set (and have clicked “Update Plot” to have your preferences processed), click the “Show Values” button. A new window will pop up with a Table of Values.
   b. The first several lines of the Table will provide information that describes the data set, often called “metadata”, such as the name of the variable, what subset of the data is included in the file, and what time range. Make sure to keep this metadata with the rest of the data when you copy it into Excel. This way you'll be able to easily keep track of which data you have!

2. Copy the data from the browser (note that these instructions are for Internet Explorer running on a PC, and may need to be modified for other platforms):
   a. In this new window, select all. You can do this by clicking anywhere in the window and then typing “Ctrl-A”. Or you can right-click in the window, which will pop up a menu, and then choosing “Select All” from the options.
   b. Next, copy this data. Again there are two options. You can use the keyboard shortcuts, and type “Ctrl-C”. Or you can right-click and choose “Copy” from the pop-up menu.

3. Paste the data into Excel:
   a. Now open your Excel worksheet and go to the tab where you want to put the raw data. Click in the A1 cell.
   b. Paste the data, either by typing “Ctrl-V”, by clicking “Paste” (located at the left under the “Home” tab), or by right-clicking in the A1 cell and choosing “Paste”.

4. Convert the data from text to columns:
   a. Now, we have the data in Excel, but we can’t manipulate it very well because all the data for each row is lumped into one cell. We want to split out each data value into its own cell.
   b. Starting at the row where the column headers are located (probably around row 7), highlight the A column down to the end of the data.
   c. Click on the Data tab at the top of the window, and then choose the “Text to Columns” wizard (located a little to the right of center).
   d. A dialogue box will pop up to help you through the process.
   e. The first page of the wizard asks you to identify whether the data is “Delimited” or “Fixed width”. In most cases, the My NASA Data data will be “Fixed Width”, so select that option and click “Next”.
   f. The next page of the wizard gives you a chance to check whether the column breaks make sense and to adjust them as necessary. Make any changes that are needed. Or, go back and switch to “Delimited” on page 1 if you notice that the columns are not lining up as you expected. Once you are satisfied with the columns, click “Next”.
   g. The final page of the wizard allows you to designate what kind of data values are in each column and a destination for the data. For the purposes of the Entergy curriculum, we’ll just accept the defaults and click “Finish”.
   h. Now your data should be in beautiful columns and the values should make sense. It's always a good idea to double check that nothing crazy happened!
My NASA Data isn’t working! What should I do?

1. Google Chrome works best. Internet Explorer does not work well at all.
2. Double check that you entered everything correctly. Especially check that you have the right data set and that you have entered dates and latitude/longitude values within the range of available data. Usually the user interface will prevent you from entering invalid data ranges, but sometimes there are glitches.
3. Refresh the browser and/or restart the browser. Occasionally, a fresh start is the easiest way to clear out any mistakes or glitches.
4. Update your browser and/or JAVA. If you have older versions of the software, then you might find that some functionality is lost.
5. If you’re still struggling, consider whether problem might be at the My NASA Data website. It might be a temporary problem, in which case taking a break and returning to the site at a later time could be a good choice. Or it could be a more significant problem, in which case you’ll want to explore the “help” resources provided by My NASA Data (link in upper right hand corner of page).
6. Send Eco-Schools USA an email for assistance! Eco-schoolsusa@nwf.org

How do I print or save a map or graph?

1. Use the “Print” button to generate a version of your map or graph that is suitable for saving or printing. Once you click on the “Print” button, a new window will pop up with your map or graph.
2. Print a map or graph by using the print option on your browser.
3. Save a map or graph in one of two ways:
   a. By choosing “Save as” in the browser. Use the defaults to save as a “Web Archive, single file (*.mht).”
   b. By right clicking and choosing “Save picture as...”. Use the defaults to save as a *.png file.
4. When saving, make sure to give your new file a descriptive name and put it somewhere that you’ll remember!

How do I find my latitude and longitude?

A number of sites help you find your latitude and longitude. For example:

Lesson 1: A Green Revolution
An Introduction to Eco-Schools USA

GRADE LEVEL
9-12

TIME NEEDED FOR COMPLETION
2-3 class periods or 1.5-2 hours, divide based on time and classroom dynamics

STANDARDS
LA GLEs and NGSS alignments are found in the Appendix starting on page A-1

PREREQUISITE KNOWLEDGE
None

MATERIALS
- Science Notebook
- Access to a computer with internet access

ACADEMIC VOCABULARY
environmental sustainability, social responsibility, stewardship

*SPECIAL NOTE*
Please check that links to videos are not blocked by your district. If blocked, use district protocol to allow viewing access.

STUDENT OBJECTIVES
- Students will begin to use the Eco-Schools USA 7-Step Framework, Pathways to Sustainability and Points-Based Awards System to define and evaluate environmental sustainability. Evaluation to be measured by Eco-Schools USA environmental audits.
- Generate a collection of environmentally sustainable ideas through collaboration with peers that will provide opportunities to engage the school and community.
- Develop a plan for how to engage and carry out the school, in part or whole, in an energy audit.

LESSON LINKS
Can be found under Web Reference unless noted below.
- Eco-Schools USA Student PowerPoint for grades 9-12 – http://bit.ly/1n4ffAE
- Eco-Schools USA Video - the link takes you to SchoolTube, but it can also be found on YouTube and Vimeo – http://bit.ly/16fJlJF

TEACHER BACKGROUND
Overview
Students will learn about the Eco-Schools USA program, specifically, its purpose, the 7-step framework, the 10 Pathways to Sustainability, and the 3-tiered award system. Each pathway has an environmental audit associated with it and for the focus of this curriculum we will be performing the energy audit. This audit will be analyzed and later an action plan will be developed and put into play based on the data your students collect.

Preparation
- Talk to your administrators about the program – get them involved.
- Send home a parent letter – example found in lesson links
- Please read the Cool School Challenge information found at the links under Web References.
- Print out the number of energy audits based on student groupings, i.e. pairs, groups of three, etc. (for lesson 2) of administrators, support staff, or parent volunteers.
TEACHER BACKGROUND continued

Eco-Schools USA
Knowing that solutions to our energy needs and mitigation to our long term environmental and societal challenges, it is our hope that the Eco-Schools USA program will strengthen the schools commitment to the environment, where eventually, sustainability becomes a part of the internal and external culture of the school. To learn about National Wildlife Federation’s Eco-Schools USA program, please see the links at the end of this lesson under Web References:
- About Eco-Schools International
- How Do I Become an Eco-School?
- What is Eco-Schools USA?

Helpful Hints
1. Students should record Essential Questions and their responses in their science notebook along with their work, i.e. sketches, action plans, data collection, analyses, etc.
2. Send out Classroom Invitations ASAP – work this into your action plan and don’t leave a lot of lag time in between pieces of your plan.
3. Before performing the audits please read the information on the Environmental Audit webpage and take a look at the Energy audit forms. (The links are found under Web References.) As teachers, being prepared is our best friend and if auditing is new for you, then reading the tools Eco-Schools uses to perform those audits is a task worth spending some time on. Taking this time now will also help put the experience into perspective as you plan out this learning experience for your students.
4. Performing the audit works best when students work in small groups and collect data from various parts of the building. Depending on how you choose to carry out the audit you may want to enlist the help of administrators, support staff, or parent

ENGAGE

Student Grouping: Individual and Whole Class
Time: 20-30 minutes

Directions
1. This will be a pre-assessment. Called First Word/Last Word and found on page 1-10, students write in their science notebook the following word(s) in a column, down the left side of the page, see example on page 10, SUSTAIN, RESPONSIBLE, and STEWARD. Students will need 4 pages in the science notebook to complete the pre- and post-assessments.
2. While students are doing this make 3 class Circle Maps. Write in the center circle each of the three vocabulary words. Post these maps on the class where students will have the opportunity to add to them over the next several days. Circle maps are used as ways to define things. In this instance we are defining vocabulary words. This is important to convey to your students. Be sure to let your students know the appropriate time to get up and add to the class maps.
Lesson 1: A Green Revolution
An Introduction to Eco-Schools USA

EXPLORE

Student Grouping: Individual/Pairs/Whole Class
Time: 25 minutes

Essential Question/Statement
A. Explain the process you think a scientist goes through when developing an idea.

Directions
1. Pair up students and have them spend 2 ½ minutes each sharing their “pre-assessment first word last word.
2. 5-8 minutes-At this point have the students write the Essential Question and answer it on their own or together with their partner. Next pick on 2 or 3 individuals/groups to share with the class. We will revisit this question again later.
3. Have students use classroom resources to find definitions for environment, sustainability, social, responsibility, steward, environmental sustainability, social responsibility, and stewardship. They should continue working in their science notebooks.
4. Watch two movies from Young Voices in Climate Change, Team Marine, 5:42 in duration and Green Ambassadors, 4:24 in duration. Watch as a class or in pairs. Have students record their thoughts in their science notebook along with the date and name of the movie. Give students the opportunity to share thoughts regarding the two films.

EXPLAIN

Student Grouping: Whole Class/Triads
Time: 40 minutes

Essential Question
B. What and/or who has helped you form your thoughts on environmental sustainability, social responsibility, and stewardship?

Directions
1. As students gain new learning and insight remind them to add to the class circle maps.
2. Write the 10 pathways on the board/smart board/whiteboard.
3. Workings in groups of 3 have students choose two pathways that inspire them.
4. With the two chosen pathways students will come up with an idea(s) for making a change at school. Students should continue recording their thoughts and ideas in their science notebook.
5. Let each group communicate their ideas to the class. (Make notes or copies of students ideas for later use)
6. Together decide on a working definition for environmental sustainability, social responsibility, and stewardship. Example definitions:
   a. Environmental sustainability-meeting the needs of the present without compromising the ability of future generations to meet their needs.
   b. Social responsibility-usually refers to businesses/organizations and means ensuring that other people’s quality of life are not compromised to fulfill the business/organization’s expectations and demands.
   c. Stewardship-The careful and responsible management of natural resources and ecosystems for the benefit of present and future generations as well as the encouragement to actively participate in change.
Lesson 1: A Green Revolution
An Introduction to Eco-Schools USA

ELABORATE

Student Grouping: Whole Group & Pairs or Triads
Time: 20 minutes

Essential Questions
C. What connections can you make between our focus words, your ideas, and the Eco-Schools USA Program?
D. What potential benefits do you see could be the result of implementing the Eco-Schools USA Program as well as potential deterrents to the implementation of the program?

Directions
1. At this point ask students, “Who would like to see their idea(s) come to fruition?”
2. Introduce students to the Eco-Schools USA program via the Eco-Schools USA Student PowerPoint, titled Knowledge is Power (found at http://bit.ly/1n4ffAE - choose grades 9-12) (allow time for students to ask questions).
3. Have students work in groups of 2 or 3 to answer the Essential Questions. Have each pair or triad share in some way, either orally or on a class Post-It.

EVALUATE

Student Grouping: Individual
Time: 15-30 minutes

Choose an evaluation tool for your class or let your students choose from one of the following.

1. Concept Quiz - found on page 1-6
2. Essay - found on page 1-9
3. Foldable - an example is found on page 1-11

Note* If your students are unfamiliar with Foldables, in the interest of time, you may choose to make the Foldables for your students and have them enter the information for you to assess. See three tab foldable PowerPoint for details. In addition, the assessment could be made available online, via Blackboard or Google Docs, where students could then retrieve and complete for homework.

Reading Extensions
Reading Extensions can be used in many ways from homework assignments to opportunities for class discussion. The Reading Extensions Student Instructions and Article Summary Rubric, found on page 13 and 14, can be used to assess students’ summaries of the articles they read.

Environmental Sustainability
First Net Zero School To Open in Texas
http://www.wfaa.com/story/local/2015/04/01/13749426/

More Colleges Adding “Green” to School Colors

Social Responsibility
Plea for Help to Tackle Invasive Plant at West Cumbria Nature Reserve
READING EXTENSIONS continued

BP – From Social Responsibility to Environmental Catastrophe

Entergy’s Social Responsibility Performance
https://vimeo.com/26335959

Stewardship
City Council Votes to Continue Research into Plastic Bag Ban

In Cherry Hill, Menendez Presents Eco Incentives Plan

New Research Suggests Early Family Influence Helps get Kids Interest in the Outdoors
http://www.post-gazette.com/pg/11212/1164135-358.stm

WEB REFERENCES

Alliance for Climate Education, ACE
http://www.acespace.org/

Eco-Schools International
http://www.nwf.org/Eco-Schools-USA/About-Eco-Schools-USA.aspx

How to Become an Eco-School
http://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School.aspx

Eco-Schools USA Environmental Review

Young Voices on Climate Change

Young Voices on Climate Change-Team Marine

Young Voices on Climate Change-Green Ambassadors
http://www.youngvoicesonclimatechange.com/movie_green-ambassadors.php

Cool School Challenge, CSC – All need challenge pieces are found at this web address
Lesson 1: An Introduction to Eco-Schools USA

Mark and Kellie decided to form a committee that focused on greening their school campus. Not only was it important to them to focus on sustainability issues but they also wanted to be actively apart of making change in their school and community. They broke the committee up into three smaller groups. One group focused on ways to lower energy costs and reduce waste at school. The second group worked on ideas to engage other students and staff at school in making a difference while the third group worked to engage local businesses and community members in their efforts.

Choose the word that best summarizes the following scenario.

A. Environmental sustainability
B. Social responsibility
C. Stewardship
D. All of the above

_____ points out of 20

I. Answer
A. O B. O C. O D. O

_____ points out of 15

II. What is the main concept behind the question?
1. Comprehension of academic vocabulary
2. Recycling
3. Sustainability
4. Energy Efficiency

_____ points out of 25

III. Provide the reasoning for choosing your answer in part II.
IV. Why are the other responses in part I not the best answer choice?

A. 

B. 

C. 

D. 

Use the rest of this page if more room is needed to fully communicate your thoughts.
Lesson 1: A Green Revolution
An Introduction to Eco-Schools USA

TEACHER ANSWER KEY
Answers may vary.

1. D

2. 1

3. Answers will vary. Comprehending academic vocabulary is the key concept. You have to understand the definition of each answer choice before you can make an informed decision.

4. Answers will vary.
   A. Not the best answer. Environmental sustainability is what group one is working on.
   B. Not the best answer. Group 2 is working on stewardship by working to engage other students and staff at the school.
   C. Not the best answer. Social responsibility is the focus for group three who is actively working to engage members of the community including businesses in the school’s green efforts.
   D. This is the best answer choice because each of the focus words is presented in the scenario.
Application Essay

Business plans are utilized the world over in order to create a viable concept for an idea. Create a brief outline or short synopsis demonstrating your green plan. I am looking for evidence that you understand environmental sustainability, social responsibility, and stewardship.

What Is the Expectation?

Use new lesson knowledge and/or Reading Extensions to support your position

Visual representations if applicable

Key vocabulary

Evidence of on grade level spelling and grammar usage
FIRST WORD/LAST WORD EXAMPLE

STEP 1

Your pre-assessment should go on the left page of your notebook. This is only an example. Please modify to meet your needs.

STEP 2

Set up your POST assessment on the right page, adjacent to your PRE-assessment.
Lesson 1: A Green Revolution  
An Introduction to Eco-Schools USA

STEP 3

This shows the pre- and post-assessment side by side as your science notebook should look.

FOLDABLE EXAMPLE

STEP 1

1. This foldable is called a “three tab foldable”. Note that you can have your students take notes regarding this lesson to the left of the foldable.
2. Only one page in the science notebook is needed.
3. DO NOT glue until the end.
Lesson 1: A Green Revolution
An Introduction to Eco-Schools USA

STEP 2

1. Fold a piece of paper or construction paper (colored notebook paper can be found at Walgreens or CVS) along the vertical line of symmetry (hot dog).
2. Measure 21cm, make a tic mark, and cut off the extra.
3. Now make a tic mark at 7cm and 14cm.

STEP 3

Cut from the bottom to the fold going through the tic mark. Cut only the top page.
Lesson 1: A Green Revolution
An Introduction to Eco-Schools USA

STEP 4

Write each of the three focus words on one of each of the three tabs illustrated.

For each focus word you will define the word and give at least one example with details.
Lesson 1: A Green Revolution
An Introduction to Eco-Schools USA

STEP 6

Add glue to the back – remember just like in elementary school, dot, dot not a lot or line, line make it fine...

STEP 7

Your final page for assessment should look something like this with detailed information on the inside of the three tabs.

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GRADE LEVEL
9-12

TIME NEEDED FOR COMPLETION
2-3 class periods or 1.5-2 hours, including conducting the audit

STANDARDS
LA GLEs and NGSS alignments are found in the Appendix starting on page A-1

PREREQUISITE KNOWLEDGE
- Lesson 1: An Introduction to Eco-Schools USA
- Ability to use pre-populated Excel spreadsheets

MATERIALS
- Science Notebook
- Access to a computer with internet access
- For teacher: Cool School Challenge Toolkit – link found under Web References
- Energy Audit, found in the appendix on page B-1

ACADEMIC VOCABULARY
environmental audit, carbon calculator, greenhouse effect, greenhouse gases, CO₂ emissions, reduction

STUDENT OBJECTIVES
- Identify reasons an energy audit is performed and explain what businesses, organizations, home owners, etc. can learn from them.
- Conduct an energy audit
- Input data and analyze results from energy audit
- Develop and adopt an energy action plan based on analysis

LESSON LINKS
Can be found under Web Reference unless noted below.

TEACHER BACKGROUND
Overview
The nation's school districts spend more than $7.5 billion a year on energy. Schools are the largest energy consumer in many municipalities. But up to 30 percent of that energy is used inefficiently or unnecessarily. This lesson will provide students the opportunity to investigate energy consumption at school. Utilizing our energy audit materials (our energy audit and the audit used for the Cool School Challenge are the same) students will collect and analyze data, input data into an energy analysis spreadsheet, report findings and develop a plan based on conclusions. This lesson is necessary for students to complete as it is the basis for the action pieces associated with the curriculum. Implementing the plan developed by students will be carried out in the last lesson of the curriculum. Please stop here and read Lesson 12. This will let you know where you are headed and allow you to plan accordingly.

Preparation
1. Print out energy audit (Note: CSC and Energy audits are the same.) based on student grouping if you did not do so in Lesson 1. You will be using pages 3-5 of the audit pages for your classroom. Remember pages 6 to the end are for large groupings or entire school auditing.
2. At this time you will have received classroom “RSVPs” from those who want to participate in the audit via the invitation you sent out in Lesson 1. Get a school map and develop a system that will allow students to break into groups and audit approved spaces.
3. Review the Classroom Carbon Calculator as this is what each auditing group will utilize to input collected data.

Helpful Hints
1. Please read over materials in the CSC toolkit to better prepare yourself and your students for the energy audit.
2. Remember, you may want to invite adult members of the Eco-Action team or parent volunteers and/or administrators to work with groups as they complete the audit (classroom management tip).
Lesson 2: LIGHTS, CAMERA, ACTION
Conducting an Energy Audit

2-2

ENGAGE

Student Grouping: Whole Group & Small Group
Time: 30-40 minutes

Essential Questions
A. When performing an energy audit what types of devices and or appliances will you be looking for?
B. What can be learned from doing an energy audit?

Directions
1. Students work in small groups to answer the Essential Questions. They can add to their list later if later if needed.
2. Go over the audit forms found under Web References, and assign student groups their room(s) they will be auditing. *SET EXPECTATIONS – who will do what, noise level, etc.

EXPLORE

Student Grouping: Small Group
Time: 30-50 minutes

Essential Question
C. What did you learn from performing the audit? Was there anything you didn’t understand or you found challenging?

Directions
1. Answer Essential Question after performing the audit.
2. Use the Cool School Challenge, CSC audit forms to complete an energy audit of the assigned rooms. Working together audit should take 4 students 8-10 min. per classroom

EXPLAIN

Student Grouping: Small Group
Time: 50-55 minutes

Essential Questions
D. What is the greenhouse effect? What are examples of three most common greenhouse gases found in the atmosphere?
E. How long does CO$_2$ stay in the atmosphere? Why is that a problem? (See Web References)
F. What is the importance of data collection?

Directions
1. Any additions to the Essential Questions in section one can be done now.
2. Student groups will need to work together to input their collected data into the CSC Carbon Calculator.
3. As a whole group or student groups – work to answer Essential Questions.

Tips
1. Remember even though there are 13 tabs we will be utilizing only:
   Welcome, Electricity Info, Classroom Lighting, Energy Vampires, Other Devices (optional), Heating, Audit Summary, and Methodology
2. Transportation, classroom trash, classroom paper, plastic water bottles, beverage cups can also be audited but are not a part of this lesson.
3. Students input data into orange boxes and the green boxes will automatically populate.
4. To scroll up and down within each spreadsheet use the up and down arrows.

Continued on next page.
EXPLAIN continued

Tips continued

5. Depending upon student ability will depend on how you choose to have your students input data. Please make sure you have looked over the Carbon Calculator before presenting to students. Here are a few options for inputting data:

- Students working with their audit group
- Teacher working with audit group
- Volunteer working with audit group

ELABORATE

Student Groupings: Small Group
Time: 30 minutes

Essential Questions
G. What is the purpose for providing a summary, action plan, and pledge to each audited class? Explain your thoughts.

H. What connections can you make between what you know about the Greenhouse Effect and the energy audit work you have done?

Directions

1. It’s time to create a summary for the audited classrooms. It is important audited classes know where they stand, are able to make changes, and see results. You will need the Climate Action Plan and the CSC Pledge (links found under Web References). These are both templates and I suggest having the students create their own action plan. The summary should include the following information:

ELABORATE continued

Directions continued

a. Print out the audit summary-only pre-survey information will be visible
b. On a new sheet of paper, create Energy Saving Tips, something that can be posted in the audited room. Use the Action Plan Template as an example. Tip: suggestions can be found in the Toolkit and under the Energy Pathway, Top Ten Tips. Be sure the teacher’s name and room number are on the plan. Make copies of the Action Plans that students create or have them make specific notations in their notebooks as this information will be needed in the last lesson during the final analysis and evaluation.

c. Lastly, each group needs a copy of the CSC Pledge. This will need to be addressed within the audited class and returned to the student group’s teacher.


3. The next action requires both teacher and student participation.

a. Teacher – Place the audit summary and pledge in the audited teacher’s box.

b. Student Groups – Staple or thumb tack the action plan in a highly visible location in the audited classroom.


*Special Note* What if my students audit a common area where no one teacher is assigned? Simply staple or thumb tack the action plan to the wall where it will be seen and read by those who enter and leave the area. The teacher can decide how to manage the audit summary and pledge. Potential Option – send a summary email to staff about common areas’ energy consumption.
**EVALUATE**

**Student Grouping:** Individual  
**Time:** See below

Please choose from the assessment tools below or you may allow students to choose the assessment that will best demonstrate their understanding of the content.

1. Concept Quiz - found on page 2-5  
2. Essay - found on page 2-8  
3. Flyer - found on page 2-9

**WEB REFERENCES**

**Cool School Challenge – CSC: Carbon Calculator**  
You will need to choose your grade band, 3rd-6th or 7th-12th. Once chosen you can access the toolkit, audit forms, school tally sheet, classroom participation poster, climate action plan, and pledge template.  
http://www.coolschoolchallenge.org/materials.aspx  
Suggested numbers of copies –

- Audit Forms: one per student group  
- School Tally Sheet: one per student group  
- Classroom Participation Poster: one per audited classroom  
- Climate Action Plane: one per student group  
- Pledge Template: one per student group

**How long does CO₂ stay in the atmosphere?**  
http://www.theguardian.com/environment/2012/jan/16/greenhouse-gases-remain-air

**Energy Pathway – Top 10 Tips**  

**READING EXTENSIONS**

Reading Extensions can be used in many ways from homework assignments to opportunities for class discussion. Provide students with the Reading Extensions Instructions found on page 13. Use the Article Summary Rubric to assess found on page 14.

**Pajaro Valley Schools Earn Energy Star Certification**  
http://www.santacruzsentinel.com/ci_18772365

**Memphis Schools Get Energy Savvy**  

**Lanier Middle School Earns Kudos for Eco-Friendly Action**  

**At Boston Latin, A Celebration of A Youth Green Movement**  
Name: ____________________________________________ Date: __________

Science Concept Quiz

Lesson 2: Conducting an Energy Audit

Conducting environmental audits allow you to apply which of the following science practices?

A. Observations, data analysis, and computation
B. Data collection, drawing conclusions, and communicating results
C. Comparing hypotheses, theories and research
D. Both A and B

_____ points out of 20

I. Answer
   A. ☐   B. ☐   C. ☑   D. ☐

_____ points out of 15

II. What is the main concept behind the question?
   1. Being a Scientist
   2. Science Practices
   3. Going Green
   4. Environmental Audits

_____ points out of 25

III. Provide the reasoning for choosing your answer in part II.
IV. Why are the other responses in Part I not the best answer choice?

A. 

B. 

C. 

D. 

Use the rest of this page if more room is needed to fully communicate your thoughts.
TEACHER ANSWER KEY

1. D

2. 2

3. Answers will vary. The question wants to know if you are able to identify science practices – things you participate in when you do science.

4. Answers will vary.
   A. This is a good answer, but so is B. The listed practices are utilized when learning about and doing science.

   B. This is a good answer, but so is A. The listed practices are utilized when learning about and doing science.

   C. Comparing hypotheses and theories are not practices in science, however formulating a hypothesis is. Learning about theories and doing research help us to perform our science practices with more focus.

   D. This is the correct answer. Both A and B are science practices that all who participate in science use at some time or another during an investigation.
Lesson 2: LIGHTS, CAMERA, ACTION
Conducting an Energy Audit

Application Essay

You have been invited to speak to your district’s high school green clubs about the importance of energy audits and what you have learned as a result of student led audits on your campus. Write a summary or outline for your upcoming speech.

- What do you need to be sure to include? What will be your opening, your hook?
- Why is environmental auditing important – link to real world problems and solutions.
- Explain the auditing process and what your school learned from the experience.
- Other tips or highlights of importance.

What Is the Expectation?

Use new lesson knowledge and/or student readings to support your position

Visual representations if applicable

Key vocabulary

Evidence of on grade level spelling and grammar usage
CREATING AN ENERGY FLYER

DIRECTIONS

Using a computer program such as Photoshop or Publisher or using your artistic abilities create a flyer that can be posted within the local community such as the library, grocery store, or community/recreation center. I am looking that you understand the connection between our current energy practices and problems and that you are able to convey the need for energy conservation and solutions in the form of tips.

**Purpose:** The flyer will inform the public regarding energy practices, importance of conserving, and include energy conserving tips.

**Audience:** Any person who can read from young to old.

**Medium:** Limitations-flyer will not be smaller than 8.5 X 11 or larger than 9 X 12. Flyer will not include 3D elements.

**DUE:** ________________________________________________

**Brainstorming Ideas – Quick Sketch**

Utilize the area below.
LESSON 3: THIS BLANKET IS MAKING ME HOT
Greenhouse Gas Investigation

GRADE LEVEL
9-12

TIME NEEDED FOR COMPLETION
2-3 class periods or 1.5-2 hours

STANDARDS
LA GLEs and NGSS alignments are found in the Appendix starting on page A-1

PREREQUISITE KNOWLEDGE
• Basic understanding of biogeochemical cycles – carbon, nitrogen, and water

MATERIALS
• Science Notebook
• Thermometers, 3 per group of 2-4
• Glass beakers (or other clear glass container), 3 identical containers per student group
• Paper towels
• (Optional) Plastic cling wrap, 2 small pieces per student group
• Handout: Data Table, 1 per group, found on 3-5 and 3-6.
• Graph paper, 1 per student group
• Access to warm water (for paper towels)
• Sunny location or heat lamp

ACADEMIC VOCABULARY
greenhouse gases, Greenhouse Effect

STUDENT OBJECTIVES
• Model the Greenhouse Effect
• Collect temperature measurements and identify patterns
• Summarize investigation findings and explain how it is a model for understanding the Greenhouse Effect.

LESSON LINKS
Can be found under Web Reference unless noted below.

TEACHER BACKGROUND
Overview
The news prevalently discusses the impact greenhouse gases and/or emissions have or do not have on the environment. This lesson provides students with the opportunity to learn exactly what are greenhouse gases, their significance in the atmosphere, and the role they play in energy and climate change.

Some greenhouse gases occur naturally and are released into the atmosphere through natural processes and human activities and others are strictly created and released through human activity. All greenhouse gases in the atmosphere can absorb the radiant heat that the Earth’s surface emits, and then re-emit that heat back towards the surface, thus creating the greenhouse effect. Common greenhouse gases include carbon dioxide, methane, nitrous oxide, and fluorinated gases, such as hydrofluorocarbons and perfluorocarbons.

While the warming trend is small even minute changes over time in global temperatures can cause significant changes in our environment.

Preparation
• Gather materials needed for the lab experiment
• Make copies of needed data sheets
• If you are not familiar with Thinking Maps please follow the link to learn more, found under Web References at the end of the lesson.
ENGAGE

Student Grouping: Small Group
Time: 20 minutes

Essential Questions

A. Why do you think the air inside a greenhouse or a car is so much warmer than the outside air? Heat energy from the sun passes through the glass and is retained within the greenhouse. Because the energy stays inside the greenhouse, the inside air is much warmer than the air outside.

Directions

1. Have a discussion with students: “Have you ever been inside a greenhouse?” If no one has, ask if they have been inside a car that has been parked in the sun all day. Before you continue the discussion have students respond to Essential Question A, in their science notebook.
2. Explain that what they experience inside a car is similar to what we call the greenhouse effect and that they will be conducting a greenhouse effect investigation to better understand the process.
3. Have students use a Circle Map to address what they already know about the greenhouse effect. Critical to have students include their frame of reference which let you know where they gained this knowledge. A link to Thinking Maps is found under Web References. Use the following guiding questions as they create their Circle Map in their science notebook-
   a. What is the greenhouse effect?
   b. Is it a bad thing?
   c. Could we live without it?
4. Allow students to share their maps with a student nearby and then discuss briefly with the class.

*NOTE* Greenhouse gases act somewhat like windows in a greenhouse, trapping the sun’s energy near Earth’s surface. The process by which air warms in a greenhouse is not identical to the greenhouse effect. While greenhouse gases absorb and reemit heat radiating from Earth’s surface, the glass in a greenhouse traps the heated air.

EXPLORE

Student Grouping: Individual or Whole Group
Time: 15-30 minutes

Essential Questions

B. Name some greenhouse gases and their sources.
C. *How is the lifetime of an individual greenhouse gas molecule, such as CO₂ different from the lifetime of a concentration of the same greenhouse gas?*

Directions

1. Ask students to answer Essential Question B in their science notebook. If students having a hard time getting started ask the class as a whole and see if you can generate some ideas. Next steps would be to write the gases and their sources on the “board”
   a. Water vapor- evaporation from Earth’s natural water cycle
   b. Carbon dioxide (CO₂)-burning fossil fuels and plant matter, deforestation, volcanic eruptions
   c. Methane (CH₄)-decomposition/decay, livestock waste, decomposing waste in landfills
   d. Nitrous oxide (N₂O)-fertilizer production, burning fossil fuels and wood, agricultural soil processes (nitrification and denitrification)
   e. Synthetic gases (e.g., fluorinated gases, CFCs)-industrial processes, manufacturing
2. *Optional: Utilize this website to learn more about greenhouse gases.*
EXPLAIN

Student Groupings: Small Group
Time: 45 minutes

Essential Questions
D. What factors were "controlled" in this experiment? Why would we be unable to trust the results of the experiment if these variables were not controlled?
E. If the thermometers in the covered glass containers did NOT indicate higher temperatures than the uncovered thermometer, what factors could have produced your results? Explain any possible scientist error - what would you have done differently?
F. Gases in Earth’s atmosphere, such as carbon dioxide, act much like the glass did in this experiment. Why did temperatures increase in the covered/dry container more than in the uncovered container? How do you think increasing amounts of carbon dioxide will affect temperatures on Earth?
G. Water vapor is a natural greenhouse gas. How does water vapor affect air temperature? How do you think temperature would be affected by adding other greenhouse gases?

Directions
1. Divide class into groups of 4. Each group should have-
   a. 3 thermometers
   b. 3 identical glass containers
   c. 2 small pieces of plastic cling (optional)
   d. 1 paper towel
   e. 1 piece of graph paper
2. All thermometers should read the same temperature. 3 students will be responsible for reading the thermometers and one student will record the data.
3. Each group:
   a. Either in a sunny spot (direct sunlight), open sidewalk or under a heat lamp, place 1 thermometer in an uncovered glass container.
   b. Place 1 thermometer in a second glass container and cover the top of the container with plastic wrap (if you are using a jar or drinking glass, you can dispense with the plastic wrap by simply turning the glass upside down).

*NOTE* This last scenario with the damp paper towel has been shown to have the most variability in the classroom. To demonstrate the ability of water vapor to retain heat most effectively, warmer temperatures are required.

4. In student science notebooks ask them to predict which environment will be the warmest after 20 minutes.
5. Instruct students to take initial readings from all 3 thermometers and record this information in the data table.
6. Students continue collecting and recording temperatures every minute for 20 minutes, recording temperatures in the data table. (The covered/damp container should become the warmest, and the uncovered container should remain the coolest.)
LESSON 3: THIS BLANKET IS MAKING ME HOT
Greenhouse Gas Investigation

EXPLAIN continued

7. Next, tell students to move the thermometers away from the heat sources, keeping the covered thermometers covered. Ask students to observe which environment retains the most heat and which temperature drops the fastest. (The covered containers should retain more heat. The uncovered container should lose heat fastest.)

8. Instruct students to graph all 3 scenarios - uncovered, covered/dry, covered/damp on a single graph. Students can use 3 different colored pencils to graph, or use symbols on each line to differentiate between the 3 treatments. Alternately, students can use a computer graphing program.

9. After groups have completed graphing the experimental data, begin a class discussion using Essential Questions D-G as well as reflecting in their science notebook.

ELABORATE

Student Groupings: Individual
Time: To be completed at home

Directions
Have students write a brief research paper to explain how different activities are linked to various greenhouse gas emissions. Ask them to be specific when explaining how activities generate greenhouse gas emissions. For example, why does burning a forest result in carbon dioxide emissions? How does raising livestock contribute to methane emissions?

EVALUATE

Student Grouping: Individual
Time: 15-20 minutes

Choose from one of the two assessment pieces or allow your students to choose which tool will best demonstrate their understanding.

1. Concept Quiz-found on page 3-7
2. Essay-found on page 3-10

WEB REFERENCES

Facing the Future
http://www.facingthefuture.org/

Thinking Maps®

Greenhouse Gas

Greenhouse Gas Emissions
http://www.epa.gov/climatechange/emissions/index.html
LESSON 3: THIS BLANKET IS MAKING ME HOT
Greenhouse Gas Investigation

DATA TABLE

GROUP MEMBERS

HYPOTHESIS
Predict which one of the three environments will be the warmest after 20 minutes, and explain why you expect this to be the outcome.

PROCEDURE
1. Make sure all 3 thermometers read the same temperature.

2. Near a heat source, place one thermometer in an uncovered glass container.

3. Next to the uncovered glass container, place one thermometer in a second glass container. Cover the top of the container with plastic wrap.

4. Next to the second glass container, place one thermometer in a third glass container with a damp paper towel that has been held under warm water. Cover the top of the container with plastic wrap.

5. Make sure that all thermometers are equidistant from the heat source so that they receive the same amount of heat energy.

6. Record the temperature of all three thermometers every 60 seconds for 20 minutes. Record data below.

7. After 20 minutes, move the three containers away from the heat source and observe what happens to the temperature in each container.
DATA TABLE

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Temperature (°Celsius)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Uncovered</td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
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<td>20</td>
<td></td>
</tr>
</tbody>
</table>

RESULTS and ANALYSIS
Answer these questions in your science notebook.
1. Which environment warmed the most?
2. After you removed the containers from the heat source which one retained the most heat?
3. What factors were “controlled” in this experiment? Why would we be unable to trust the results of the experiment if these variables were not controlled?
4. If the thermometers in the covered glass containers did NOT indicate higher temperatures than the uncovered thermometer, what factors could have produced your results? Explain any possible scientist error—what would you have done differently?
5. Gases in Earth’s atmosphere, such as carbon dioxide, act much like the glass did in this experiment. Why did temperatures increase in the covered/dry container more than in the uncovered container? How do you think increasing amounts of carbon dioxide will affect temperatures on Earth?
6. Water vapor is a natural greenhouse gas. How does water vapor affect air temperature? How do you think temperature would be affected by adding other greenhouse gases?
This set up was used to demonstrate how temperature varied in three types of systems in an effort to better understand greenhouse gases and the greenhouse effect. Which of the following express limitations to this model?

A. Each container should be made of a different material.
B. This model is an exact representation of our atmospheric conditions.
C. Each model represents a different Earth system.
D. Greenhouse gases present in each container are limited in variety and quantity.

______ points out of 20
I. Answer
   A. ☐   B. ☐   C. ☐   D. ☐

______ points out of 15
II. What is the main concept behind the question?
   1. Experimental Design
   2. Limitations of Models
   3. Climate Change
   4. Greenhouse Gases

______ points out of 25
III. Provide the reasoning for choosing your answer in part II.
IV. Why are the other responses in part I not the best answer choice?

A.

B.

C.

D.

Use the rest of this page if more room is needed to fully communicate your thoughts.
TEACHER ANSWER KEY

1. D

2. 2

3. Answers will vary. Even though information regarding greenhouse gases were important to understand for the investigation the question specifically asks for the limitations related to the picture of the model which was recreated in class.

4. Answers will vary.
   A. When conducting an investigation there must be controlled variables. The containers are controls and not related to limitations of this model.
   
   B. There are several limitations to this model and for obvious reasons this is not an exact replication, i.e. the atmosphere is not made out of glass containers.
   
   C. Each model does not represent a different Earth system. Each container is a model of the atmosphere, each gathering different pieces of information.
   
   D. This is the correct answer. We are unable to create a closed system that mimics our atmosphere’s composition therefore this would be one limitation to this model.
Application Essay

After completing the investigation, discussions in class, and writing in your science notebook you have a strong foundation in regards to greenhouse gases and the greenhouse effect. Take that knowledge and explain how Earth’s atmosphere is like a blanket when referring to the greenhouse effect. Express the limitations associated with this model.

What Is the Expectation?

Use new lesson knowledge and data to support your position

Visual representations if applicable

Key vocabulary

Evidence of on grade level spelling and grammar usage
LESSON 4: WHY ALL THE WIGGLING ON THE WAY UP
Investigating CO₂ Trends

GRADE LEVEL
9-12

TIME NEEDED FOR COMPLETION
2-3 class periods or 2.5-3 hours

STANDARDS
LA GLEs and NGSS alignments are found in the Appendix starting on page A-1

PREREQUISITE KNOWLEDGE
- Students should have a strong foundation in Earth's geochemical cycles, specifically the carbon cycle.
  - EPA-Carbon cycle interactive animation
  - NASA-Carbon on the Land and in the Oceans: The Modern Carbon Cycle
- Basic understanding of the layers of the atmosphere

MATERIALS
- Science Notebook
- Computer with internet access
- Keeling Curve plot

ACADEMIC VOCABULARY
role of CO₂ and NO₂ in the atmosphere, Normalized Difference Vegetation Index (NDVI), Charles Keeling, linear regression

STUDENT OBJECTIVES
- Access and collect CO₂, vegetation, and NO₂ data from NASA Earth observing satellites
- Analyze and compare datasets and compute a linear regression of the data.
- Determine how seasonal cycles in vegetative cover influence atmospheric CO₂.
- Determine the long-term trend caused by fossil fuel burning and deforestation.

LESSON LINKS
Can be found under Web Reference unless noted below.
- Tech Tips found on page 15
- Monthly NDVI, found on page 4-4
- Monthly Tropospheric Total Column NO₂, found on page 4-5

TEACHER BACKGROUND
Overview
Starting in 1958, Charles D. Keeling from the Scripps Institute of Oceanography began measuring the amount of carbon dioxide (CO₂) in the atmosphere in Mauna Loa, Hawaii. He collected air in flasks (or canisters) and made careful measurements that provided some of the first evidence that humans were significantly modifying the atmospheric composition. These measurements are still made today at Mauna Loa and at about a dozen stations spanning from the North Pole to the South Pole.

This lesson will give students an opportunity to examine the CO₂ data from Mauna Loa, Alaska, and their home location. They will use this data to explore how the seasonal growth and die-off of vegetation in temperate and colder regions influences CO₂ levels. Then, they will investigate the long-term trend in CO₂ and how it relates to emissions from fossil fuel burning and deforestation.

Preparation
- Students will need access to computers and the internet to work in pairs.
  Schedule the appropriate amount of time for students to utilize the computer lab or mobile computer cart. If your campus has access to iPads or Netbooks this is ideal for each group to gather their data.
  - Print out a classroom set for pairs of students to utilize-
    - Tech Tips
    - Data collection guides
    - Mauna Loa graph
  - There are 3 articles in this lesson for students to read online. If you have students who do not have access to the internet outside of the classroom please make a copy for those students.
LESSON 4: WHY ALL THE WIGGLING ON THE WAY UP?
Investigating CO₂ Trends

ENGAGE

Student Grouping: Individual/Pairs/Whole Group
Time: 20-25 minutes

Directions
2. Students will record in their science notebook, in a format they prefer, what they know about and/or understand about the carbon cycle and CO₂. They are writing what they already know based on the article and their prior knowledge.
3. Give students 3 minutes to share with their closest partner.
   Have a brief class discussion, using a circle map or another graphic organizer to record classroom knowledge. Display this thought compilation throughout this lesson.

EXPLORE

Student Grouping: Pairs/Whole Group
Time: 45-50 minutes

Essential Questions
A. What do you notice for both Alaska and Hawaii on a single chart?
B. What do you notice about how CO₂ changes through an individual year in Alaska? What factors explain these patterns?
C. What do you notice about the long-term trend of CO₂ at these two locations? What factors might explain this trend?
D. Answer before plotting CO₂ time series. What do you think the CO₂ time series will look like for your locations?
E. Answer after plotting CO₂ time series. Describe the time series plot for your location. Does its pattern make sense in terms of what you would expect based on the plots for Hawaii and Alaska? Why or why not?

EXPLORE continued
1. Students need their latitude and longitude for this data collection. Use iTouchmaps.com if students do not have their latitude and longitude from previous lessons. Have them record this information in their science notebook.
2. Refer to the Guide to Collecting CO₂ Data for Three Locations, found on page 4-6.
3. Have students complete Essential Questions
4. Have a class discussion about student findings. Students should come to similar conclusions if work was completed successfully.

EXPLAIN

Student Grouping: Pairs/Small Group/Whole Group
Time: 30 minutes

Essential Questions
F. How does NDVI in Alaska, your location, and in the Northern Hemisphere generally change during the year? Explain and elaborate.
G. Revisit your answers to the questions in part 1 in the light of these plots. Does the distribution of vegetation confirm your hypothesis or do you need to revise your hypothesis based on this new information?

Directions
1. Have students follow the Guide to Examining Seasonal Variation in Vegetation, found on page 4-7.
2. After students have analyzed their maps have them discuss their results with another student pair.
3. Have a class discussion regarding the results centered on the Essential Questions.
4. Homework: Read: Charles Keeling and The Keeling Curve and The Mauna Loa Observatory. Both articles are quite short. They can be consolidated and printed front/back for those students who do not have access to the internet at home. Links found under Web References.
ELABORATE

Student Groupings: Whole Group/Pairs/Small Group
Time: 45-55 minutes

Essential Questions
H. Is the long-term trend quantified by the slope similar or different at your three locations? What can you conclude about how long CO₂ remains in the atmosphere relative to how long it takes for air from different regions to become well-mixed?
I. How does the trend calculated from your three locations over the short record compare to the average long-term trend estimated from the Keeling Curve?
J. How does your estimate in Gigatons of Carbon compare to the emissions from fossil fuel burning and deforestation? What might be the reason for any differences between these numbers?
K. What does your map of NO₂ indicate about where major sources of combustion are located worldwide?
L. Do you think the long-term CO₂ trend will be similar or different in the Southern Hemisphere? Explain and elaborate.

Directions
1. Have a brief discussion about the reading from the night before.
2. Refer to the Guide to Examining the Long-Term Trend in the CO₂ Time Series Data for student directions, found on page 4-8.
3. Have students answer Essential Questions as and/or after completing their data collecting.
4. After students have analyzed their maps have them discuss their results with another student pair.
5. Have a class discussion regarding the results centered on the Essential Questions.

EVALUATE

Student Groupings: Individual
Time: 10-15 minutes

Allow students to choose from the following assessments, use them all, or choose which assessment you would like students to use to demonstrate their understanding of this lesson.

1. Concept Quiz – found on page 4-9
2. Essay – found on page 4-12
3. Justified True False – found on page 4-13

WEB REFERENCES

EPA-Carbon Cycle Interactive Animation
http://www.epa.gov/climatechange/kids/basics/today/carbon-dioxide.html

NASA’s Earth Observatory-Carbon on Land and in the Ocean: The Modern Carbon Cycle
http://goo.gl/o9ytu6 (Pdf found in Lesson 4 folder)

Layers of the Atmosphere
http://www.vtaide.com/png/atmosphere.htm

Changing the Global Land Surface: The Carbon Cycle
http://earthobservatory.nasa.gov/Features/LandSurface/landsurface2.php

iTouch Maps-Locating your Latitude and Longitude
http://itouchmap.com/latlong.html

Live Access Server
http://mynasadata.larc.nasa.gov/las/UI.vm?null

Charles Keeling and the Keeling Curve
http://earthobservatory.nasa.gov/IOTD/view.php?id=5620

The Mauna Loa Observatory
http://earthobservatory.nasa.gov/IOTD/view.php?id=43182
LESSON 4: WHY ALL THE WIGGLING ON THE WAY UP?
Investigating CO₂ Trends

MONTHLY NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI) (DIMENSIONLESS)

TIME: 15-DEC-2009 00:00
DATA: /usr/local/fer_data/data/NVDI_LAND_2009_2010.nc

MONTHLY NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI) (DIMENSIONLESS)

TIME: 16-AUG-2009 12:00
DATA: /usr/local/fer_data/data/NVDI_LAND_2009_2010.nc
MONTHLY TROPOSPHERIC TOTAL COLUMN NO$_2$

Monthly Tropospheric Total Column NO$_2$ (OMI) (10$^{-15}$ molecules/cm$^2$)

TIME: 15-AUG-2007 00:00

Data Source: NO2/OMI

LAS 7.1/Ferret 6.1
NOAA/PMEL
Guide to Examining CO₂ Data for Three Locations


2. Access CO₂ time series data for two locations: Alaska (64°N, 158°W) and Hawaii (20°N, 157°W)
   a. In the Live Access Server (Advanced Edition), click on the Dataset button. Then choose, \( \text{Atmosphere} \rightarrow \text{Air Quality} \rightarrow \text{Monthly Carbon Dioxide in Troposphere (AIRS or AQUA)} \). A map will automatically appear.
   b. Under “LINE PLOTS”, select: \( \text{Time Series} \)
   c. Enter the latitude and longitude for Alaska into the appropriate boxes just below the small grey map on the left of the screen.
   d. Set the time settings in Data Range to be January 2003 to December 2009.
   e. Click Update Plot and a time series plot will appear.
   f. We want to access the data used to create this plot, so that we can do our own calculations. Click the Show Values button and then click OK to accept the defaults. The data will appear in the second window.
   g. Follow the instructions in the Tech Tips Guide to import the data into the Microsoft Excel worksheet for this lesson. Put the raw data in the tab titled “Raw Data – Temperature”
   h. Repeat steps b-g for Hawaii.
   i. Copy and paste the CO₂ data for both locations into the tab titled “3 sites” in the appropriate columns.

3. Click on the tab labeled “Chart HI + AK” The time series data plot for both Alaska and Hawaii have been automatically done for you based on the data you input.

4. After analyzing your chart for Alaska and Hawaii answer the Essential Questions above through D.

5. Access and upload “your location” data to the tab labeled “Raw – Your location”. Then copy the data to the appropriate column in the “3 Sites” tab. All three columns should now be input and automatic calculations have been made to the right. Now answer Essential Question number E.
LESSON 4: WHY ALL THE WIGGLING ON THE WAY UP?
Investigating CO₂ Trends

Guide to Examining Seasonal Variation in Vegetation

We will examine how seasonal variation in vegetation is related to the seasonal CO₂ cycle using the Normalized Difference Vegetation Index (NDVI). NDVI provides a measure of how much vegetation is growing at each location.


2. Plot NDVI for January and August 2009
   b. Under “MAPS”, select: Latitude-Longitude
   c. Set the Date to be January 2009.
   d. Click Update Plot and a map will appear. Save or print your map. Refer to the Tech Tips Guide if you are having trouble.
   e. Now, set the Date to be August 2009. Click Update Plot and a map will appear. Save or print the August 2009 map.
   f. NOTE: You may also wish to print out a map of North America for a more detailed view.

3. After analyzing your maps and talking to your peers you will answer the Essential Questions.

Carbon Cycle Schematic: Carbon is exchanged between various reservoirs in the Earth system. The ocean plays a vital role in the Earth's carbon cycle. The total amount of carbon in the ocean is about 50 times greater than the amount in the atmosphere, and is exchanged with the atmosphere on a time-scale of several hundred years.

NASA Science: Earth
1. A linear regression for each of the three locations has been conducted in the Excel spreadsheet. This slope corresponds to the average CO₂ increase in parts per million (ppm) per month over the 7-year period. These slopes have been multiplied by 12 (to convert the slope to the average annual increase in CO₂) averaged across your three locations to get a number representative of the Northern Hemisphere annual average increase.

2. Using the Keeling Curve plot, estimate the average annual slope over the entire 51 year record.

3. The average annual slope has been converted to Gtons Carbon (using the following conversion: 2.1 Gtons C = 1 ppm CO₂) to calculate how much CO₂ is added to the atmosphere each year. Note that the average annual emissions of CO₂ from fossil fuel burning worldwide is 7.8 Gtons C, and the average annual emissions of CO₂ from deforestation is 1.6 Gtons C.

4. Next, we investigate the locations of major sources of fossil fuel and biomass burning emissions using a map of nitrogen dioxide (NO₂). NO₂ and CO₂ are both byproducts of combustion and therefore have similar source regions. NO₂ has a much shorter lifetime in the atmosphere than CO₂, making it easier to identify the source regions.

5. Go to NASA’s Live Access Server, LAS: [http://mynasadata.larc.nasa.gov/las/getUI.do](http://mynasadata.larc.nasa.gov/las/getUI.do)


7. Select date August 2007. Then click Update Plot.

8. Save or print your map. Refer to the Tech Tips Guide if you need assistance.

9. After analyzing the data and talking to your peers answer the Essential Questions.
The carbon cycle includes many important processes that impact the earth system. The famous diagram from Mauna Loa, The Keeling Curve, depicts the rise of CO₂ from 1958 to 2008.

Which groupings would be considered carbon sinks, having the ability to absorb large amounts of carbon, and would therefore be disadvantageous to destroy?

A. Parking lots and buildings  
B. Trees and oceans  
C. Coal beds and natural gas reserves  
D. Farmland and factories

______ points out of 20

I. Answer

   A. O   B. O   C. O   D. O

______ points out of 15

II. What is the main concept behind the question?

1. Natural Resources  
2. Renewable Energy  
3. Change over Time  
4. Carbon Cycle

______ points out of 25

III. Provide the reasoning for choosing your answer in part II.
IV. Why are the other responses in part I not the best answer choice?
A.
B.
C.
D.

Use the rest of this page if more room is needed to fully communicate your thoughts.
TEACHER ANSWER KEY

1. B

2. 4

3. Answers will vary. The carbon cycle is made up of places where carbon is stored, where it is given off, and how it is transferred. This knowledge will allow one to best answer this question.

4. Answers will vary.
   A. Parking lots and buildings contribute to higher temperatures and don not absorb carbon.

   B. This is the correct answer. Trees and oceans are places where carbon can be absorbed. If trees are cut down then carbon cannot be absorbed. As oceans warm they are unable to store as much carbon and therefore it stays in the atmosphere.

   C. Coral reefs and natural gas reserves produce carbon in different ways.

   D. Farmland and factories also produce carbon. Even though farmland produces crops of various kinds they cannot absorb the toms of carbon released into the atmosphere like large areas of trees are able to do.
Application Essay

Based on your analyses, collaborations, and writings, provide evidence of understanding for how CO₂ varies seasonally and regionally within the northern hemisphere.

What Is the Expectation?

Accurate science relating to trends in CO₂

Evidence supporting your claims

Visual representations if applicable

Key vocabulary

Evidence of on grade level spelling and grammar usage
**Justified True or False Statements**

**Lesson 4: Why All the Wiggling On the Way Up? Investigating CO₂ Trends**

*Justified True or False Statements* provide a set of claims or statements that are examined by you. You are meant to draw on evidence from what you have learned to analyze the validity of the statements, and then describe the reasoning used to decide whether each claim is true or false.

*NOTE* Please use grade appropriate spelling and grammar.

<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>T</th>
<th>F</th>
<th>WHY I THINK SO…</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CO₂ amounts fluctuate seasonally.</td>
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<tr>
<td>2. Total atmospheric amounts, in ppm have decreased over time. The Mauna Loa graph shows a downward trend.</td>
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<tr>
<td>3. Scientists believe atmospheric CO₂ will continue to increase without human intervention and mitigation.</td>
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<td></td>
</tr>
</tbody>
</table>

Use this space to include more evidence to support your claim and or to draw a model if applicable.
LES SON 4: WHY ALL THE WIGGLING ON THE WAY UP?
Investigating CO\(_2\) Trends
4-14

GRADING RUBRIC
Assign a score of 0-3 based on the following criteria:
- Level 0 (17 pts.) = answered T or F correctly or incorrectly/no explanation
- Level 1 (23.3 pts.) = answered T or F correctly/cursory explanation
- Level 2 (28 pts.) = answered T or F correctly/deeper explanation
- Level 3 (33.3 pts.) = answered T or F correctly/complex explanation

TEACHER ANSWER KEY
Answers will vary.
1. True-CO\(_2\) fluctuates seasonally. As trees and other vegetation lose their leaves we begin to see an increase in the amount of CO\(_2\) in the atmosphere because it's the leaves that absorb the CO\(_2\). In the spring the opposite takes place; as trees and other vegetation green up we will see a decrease in the amount of CO\(_2\) in the atmosphere.

2. False-Total atmospheric CO\(_2\) amounts have steadily increase over time and significantly increased since the Industrial Revolution. The Keeling Curve, from the Mauna Loa observatory show an upward trend, not a downward trend.

3. True-Scientist believe through the vast data collecting, analysis and models that without human intervention and mitigation atmospheric CO\(_2\) will continue to rise and create a multitude of problems for the Earth system. The increase in CO\(_2\) is due in part to increases in population and not reducing carbon emission via community, industry, or government.
LESSON 5: WHEREFORE ART THOU, ALBEDO?
Investigating Ice-Albedo Feedback

GRADE LEVEL
9-12

TIME NEEDED FOR COMPLETION
2-4 class periods or 2-3 hours

STANDARDS
LA GLEs and NGSS alignments are found in the Appendix starting on page A-1

PREREQUISITE KNOWLEDGE
Links can be found under Web References to the following resources
• Understand Earth’s energy budget
• Diagram: Earth’s energy budget
• Incoming and outgoing fluxes
• Calculating percent change

MATERIALS
• Science Notebook
• Computer with internet access

ACADEMIC VOCABULARY
albedo, flux, total all-sky net flux (see Engage-Essential Question B), energy budget

STUDENT OBJECTIVES
• Use NASA Earth observing satellite data to discover the relationship between snow-ice cover and changes in albedo.
• Analyze and compare data sets to evaluate seasonal, geographic and long term trends related to snow-ice cover and vegetation.
• Differentiate between seasonal and human induced differences in Earth’s albedo.
• Hypothesize causes related to long term albedo trends.

LESSON LINKS
Can be found under Web Reference unless noted below.
• TOA All-Sky Net Flux-found on page 5-5
• Monthly Snow-Ice Data Maps found on page 5-6

TEACHER BACKGROUND
Overview
Earth’s albedo is the fraction of incoming radiation (sunlight) that is reflected into space. The Earth has an average albedo, which describes how much sunlight is reflected on average for the whole planet and the whole year. That value is about 0.3. The Earth also has a local albedo, which determines how much of the Sun’s light is reflected from a particular place at a particular time. The local albedo depends on the particular local surface, which can change seasonally as vegetation changes. It also depends on more rapidly changing things such as snow and clouds.

For reference, the values of albedo range from 0.0 to 1.0, where a value of 0.0 is for a surface that absorbs all radiation (reflects 0 percent) that strikes its surface, and a value of 1.0 represents a surface that reflects 100 percent of the radiation that strikes it.

Fresh snow has an albedo ranging from 0.75 to 0.90.
Dry dark soil has an albedo of approximately 0.13.
Open ocean has an albedo of approximately 0.10.

How fast the planet warms in response to adding greenhouse gases to the atmosphere depends in part on climate feedbacks. These natural processes can amplify/hasten the warming - a positive climate feedback - or counteract some warming - a negative climate feedback. How snow and ice respond to warming and the resultant impact on surface albedo is an important positive climate feedback. As the climate warms, snow and ice melt - the earth’s surface becomes less reflective -especially if sea ice melt, revealing open ocean, which is very dark, more solar energy is absorbed by the earth’s surface rather than being reflected back to space, causing the temperature to increase and the cycle to continue.
Overview continued

Preparation:
- Color copies of Monthly Snow-Ice Amounts
- Copies of Monthly Snow-Ice Amounts Data Worksheet per pair of students
- Sign up for a free PBS Learning - [http://www.pbslearningmedia.org/] account - must have in order to do EXPLORE.

Helpful Hints:
- Plan in advance for computer use - whether in through the lab or mobile cart.

ENGAGE

Student Grouping: Pairs
Time: 15-20 minutes

Essential Questions
A. What considerations should be given to weather and climate when analyzing the maps?
B. What is the relationship between Earth's energy budget and the two TOA All-Sky Net Flux maps?

Directions
1. Examine the two NASA satellite data maps. The maps show TOA All-Sky Net Flux for March 2010 and September 2010.
2. As students analyze the maps ask them to record similarities and differences between the maps in their science notebook. Have students use the Essential Questions as a guide during analysis.
3. Discuss responses in class.
4. Homework: Read about the relationship between snow cover and net radiation on NASA's Earth Observatory, [http://goo.gl/mOtXN2]. Provide students with the [Reading Extensions Instructions] found on page 13 and [assess their work using Article Summary Rubric] found on page 14.

*NOTE* You want to relate these maps to Earth's energy budget, found in “Prerequisite Knowledge”

EXPLORE

Student Grouping: Individual/Pairs
Time: 30-45 minutes

Essential Questions
C. What is meant by the term albedo?
D. How does albedo affect the behavior of solar radiation reaching Earth’s surface?
E. Why would you expect Greenland to have a higher albedo than its surrounding areas?
F. What role would seasonality have on Earth’s albedo and how does the Earth’s albedo change over the course of a year?
G. How do soot particles in the atmosphere affect incoming solar radiation? How might an increase or decrease in the number of particles change the intensity of solar radiation reaching Earth’s surface?

Directions
1. Students need access to a computer with internet. Be sure to schedule time for the computer lab or check out the mobile lab cart. If 1:1 or 2:1 computer access is not possible then show and share with the entire class. Link to video is found under [Web References].
2. Answer Essential Questions which come directly from PBS Learning Media associated with this interactive video piece.
EXPLAIN
Student Groupings: Pairs
Time: 45 minutes

Essential Questions
H. How has snow/ice coverage changed over time for Northern Chukchi Sea? Explain how you know?
I. How has snow/ice coverage changed over time for Beaufort Sea? Explain how you know?
J. How has snow/ice coverage changed over time for Northwestern Passages? Explain how you know?
K. What are limitations to this process for looking at change over time in snow/ice amounts?
L. Explain how changes in snow/ice amounts could affect the earth system, specifically wildlife and coastal communities.

Directions
1. Students now have a basic knowledge of albedo. Students will now examine an Arctic region that expands north, east and just west of Alaska and calculate percent change.
2. Pass out the ISCCP Satellite – Monthly Snow/Ice Amount Maps. Have your students label the following bodies of water using referenced sources; Chukchi Sea, Beaufort Sea, and Northwestern Passages.
3. Students will make observations about the maps. Their focus should be on change over time. Observations should be noted in science notebook.
4. Monthly Snow/Ice Amount-Change Over Time data sheet, found on pages 5-7 and 5-8 of this document, will be used by students to calculate percent change over time.
5. Answer Essential Questions on the bottom of the data sheet.

ELABORATE
Student Groupings: Individual
Time: Complete at home or 45 minutes in class

Directions
1. Students will choose one of the following articles to read and report on using the Rubric for Assessing Reading Extensions, found on page 14. Instructions are included for students to utilize. Links to articles are found under Web References.
   - Read A: Artic Ice is Younger, Thinner, and Disappearing
   - Read B: Not-So-Permafrost Could Release as Much Heat-Trapping Pollution as Deforestation
   - Read C: Arctic Sea Ice Hits Lowest Winter Maximum on Record (2015)
   - Read D: No Green Light for Whitening Arctic’s Melting Ice

EVALUATE
Student Groupings: Individual
Time: 20-30 minutes

Choose one of the following assessments or allow your students to choose one of the following.
1. Concept Quiz-found on page 5-9
2. Essay-found on page 5-12
3. Justified True/False Statements-found on page 5-13
LESSON 5: WHEREFORE ART THOU, ALBEDO?
Investigating Ice-Albedo Feedback

READING EXTENSIONS
Read: Arctic Is Younger, Thinner and Disappearing (2011)

Read: Not-So-Permafrost Could Release as Much Heat-Trapping Pollution as Deforestation
http://switchboard.nrdc.org/blogs/dlashof/not_so_permafrost_could_release.html

Read: Arctic Sea Ice Hits Lowest Winter Maximum on Record (2015)
http://www.cnn.com/2015/03/21/world/arctic-sea-ice/index.html

Read: No Green Light for Whitening Arctic’s Melting Ice

WEB REFERENCES
Energy Budget Explanation
http://mynasadata.larc.nasa.gov/radiation-energy-transfer/

Energy Budget Diagram
http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=E

Flux
http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=F

Definition for TOA All-Sky Net Flux
http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=T

PBS Learning Media
http://www.pbslearningmedia.org

PBS Learning Media: Earth’s Albedo and Global Warming
http://www.pbslearningmedia.org/search/?q=albedo

Calculating Percent Change
http://www.econport.org/content/handbook/Elasticity/Calculating-Percentage-Change.html

Reading: NASA’s Earth Observatory-The Relationship between Snow Cover and Net Radiation
http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD10C1_M_SNOW&d2=CERES_NETFLUX_M
TOA All-sky Net Flux:
The net amount of energy (in minus out) measured at the top of the atmosphere (see TOA definition) under All-sky conditions (meaning the combination of clear and cloudy situations as they happen to occur). This parameter is available for monthly averages and as a 72-day average from the older ERBE measurements. This parameter combines both shortwave (visible or light) and longwave (heat or infrared) energy.
ISCCP Satellite – Monthly Snow/Ice Amount Over 14 Years

Monthly Snow-Ice Amount (ISCCP) (percent) 1994

Monthly Snow-Ice Amount (ISCCP) (percent) 2000

Monthly Snow-Ice Amount (ISCCP) (percent) 2004

Monthly Snow-Ice Amount (ISCCP) (percent) 2008
LESSON 5: WHEREFORE ART THOU, ALBEDO?
Investigating Ice-Albedo Feedback
5-6

NAME: _____________________________________ DATE: __________

Monthly Snow/Ice Amount-Percent Change Data Sheet

Please label all your maps as follows...

*NOTE* Percentage equals the amount of snow/ice that is in the box. These are estimates only.

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</tbody>
</table>
Percent change from 1994 to 2008 4A-4L = __________
Percent change from 1994 to 2008 3A-3L = __________
Percent change from 1994 to 2008 2A-2L = __________
Percent change from 1994 to 2008 1A-1L = __________
Total, all map percent change 1994-2008 = __________

**Essential Questions:**
*Answer in your science notebook.*

A. How has snow/ice coverage changed over time for Northern Chukchi Sea? Explain how you know?

B. How has snow/ice coverage changed over time for Beaufort Sea? Explain how you know?

C. How has snow/ice coverage changed over time for Northwestern Passages? Explain how you know?

D. What are limitations to this process for looking at change over time in snow/ice amounts? Explain how changes in snow/ice amounts could affect the earth system, specifically wildlife and coastal communities.
Science Concept Quiz
Lesson 5: Wherefore Art Thou, Albedo
Investigating Ice-Albedo Feedback

Which statement is true using the evidence from the graph above?

A. All polar bear populations will die within 10 years.
B. Arctic ice extent has gradually increased from the 1950's to present.
C. Monthly sea ice extent increases as annual sea ice extent decreases.
D. There has been a steady decline in sea ice extent starting around 1980.

I. Answer
A. B. C. D.

II. What is the main concept behind the question?
1. Defining Variables
2. Drawing Conclusions
3. Glacial Decline and Wildlife
4. Interpreting Graphs

III. Provide the reasoning for choosing your answer in part II.
IV. Why are the other responses in part I not the best answer choice?

A.

B.

C.

D.

Use the rest of this page if more room is needed to fully communicate your thoughts.
TEACHER ANSWER KEY

1. D

2. 4

3. Answers will vary. D. Interpreting graphs is the best answer because if I can’t read the graph I am unable to answer questions related to the graph.

4. Answers will vary.
   A. Although reports suggest polar bear populations are in danger this graph does not analyze the decline in those populations.

   B. The graph shows the opposite, arctic sea ice extent has gradually decreased since the 1950’s.

   C. The monthly and annual lines do not run in opposite directions. Both monthly and annual lines are directly correlated and show gradual decrease over time.

   D. This is the correct answer. According to the graph sea ice extent has been gradually decrease since around 1980.
Application Essay

Using evidence from your work with this lesson explain ice-albedo feedback. What can be learned from studying data collected over time and specifically why is studying the ice-albedo feedback over time important?

What Is the Expectation?

Use new lesson knowledge or student readings to support your position

Visual representations if applicable

Key vocabulary

Evidence of on grade level spelling and grammar usage
**Justified True or False Statements**

**Lesson 5: Where Art Thou, Albedo? Investigating Ice-Albedo Feedback**

*Justified True or False Statements* provide a set of claims or statements that are examined by you. You are meant to draw on evidence from what you have learned to analyze the validity of the statements, and then describe the reasoning used to decide whether each claim is true or false.

*NOTE* Please use grade appropriate spelling and grammar.

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<th>F</th>
<th>WHY I THINK SO…</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Earth’s energy budget and the ice-albedo feedback loop are unrelated.</td>
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<tr>
<td>2. Wildlife is negatively affected by declining ice amounts.</td>
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<tr>
<td>3. More radiation is reflected from the deep ocean waters than from snow and ice covered areas.</td>
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Use this space to include more evidence to support your claim and or to draw a model if applicable.
LESSON 5: WHEREFORE ART THOU, ALBEDO?
Investigating Ice-Albedo Feedback

5-13

JUSTIFIED TRUE/FALSE GRADING RUBRIC
Assign a score of 0-3 based on the following criteria:

- Level 0 (17 pts.) = answered T or F correctly or incorrectly/no explanation
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- Level 2 (28 pts.) = answered T or F correctly/deeper explanation
- Level 3 (33.3 pts.) = answered T or F correctly/complex explanation

TEACHER ANSWER KEY
Answers will vary.

1. False—Earth’s energy budget and ice-albedo feedback loop are directly related. How snow and ice behave as a part of the Earth system tells us if the Earth’s budget is in sync or out of whack. When more energy is absorbed into our Earth system via the hydrosphere and atmosphere our overall climate temperatures increase. Part of this increase in temperature is due to the fact that there is less snow and ice coverage and therefore the sun’s radiation is absorbed into open waters and land masses that are no longer covered with snow and ice.

2. True—Wildlife is negatively impacted by losses in snow and ice because several species such as polar bears and seals depend on snow and ice coverage for shelter, breeding, and hunting.

3. False—More radiation is reflected from snow and ice covered areas than from open waters and uncovered land masses. White reflects the sun’s radiation while the deep dark color of open waters absorbs the sun’s radiation. *NOTE* Students may draw a model of the ice-albedo feedback and/or Earth’s energy budget.

![Earth's Albedo and Global Warming](image)

![MY NASA DATA](image)
LESSON 6: NATURALLY SPEAKING
Investigating Natural Resource Production in My State

GRADE LEVEL
9-12

TIME NEEDED FOR COMPLETION
2-3 class periods or 2-2.5 hours

STANDARDS
LA GLEs and NGSS alignments are found in the Appendix starting on page A-1

MATERIALS
• Science Notebook
• Computer with internet access

ACADEMIC VOCABULARY
natural resources, renewable and non-renewable resources, correlation, consumption, expenditure, fuel mix

STUDENT OBJECTIVES
• Examine state energy data from the Department of Energy’s State Energy Data System
• Compare and contrast a variety of state’s energy statistics
• Make observations about your state’s energy production and use and use those observations to justify a viewpoint on the state’s natural resources system.

LESSON LINKS
Can be found under Web Reference unless noted below.

TEACHER BACKGROUND
Overview
Our energy needs have been met in many ways throughout history, from fire rings and wood burning hearth’s, to oil burning lamps and steam powered engines, to solar panels and wind turbines. Today many students understand that our energy needs are met through the burning of fossil fuels and some may also understand that some of our energy needs are met through renewable energies such as solar and wind. It is most important for students who will become voters and the change-makers of tomorrow to have the facts and understand the role that all natural resources play in providing people in developed countries with the lives we are accustomed to living. How can you best support your student’s efforts to live more sustainably in light of our current and future energy needs and trends?

In this lesson students will learn how different parts of our society use energy and how that energy use has changed over time. Next students will investigate natural resources found in their state and the fuel mix used to satisfy the state’s energy needs. Electric generation fuel mixes vary from state to state and region to region, depending upon the availability and cost of fuels located there. Major changes in the generation mix can have economic and reliability impacts, especially on a regional basis (Edison Electric Institute).

Preparation
Reserve time for students to use the computer lab and or have access to a mobile laptop cart. iPads will also be a great tool if you have them available on your campus.
LESSON 6: NATURALLY SPEAKING
Investigating Natural Resource Production in My State

ENGAGE

Student Grouping: Individual/Pairs/Whole Group
Time: 30 minutes

Essential Questions
A. What types of energy related information can be found through EIA’s dashboard tool?
B. Looking below the U.S. map at the State Total Energy Rankings. Click, "Production". In what region of the country are most of the top 10 energy producing states found? What are some possible explanations for this?
C. Does there appear to be a relationship between “Consumption per Capita” and “Production”? Explain.

Directions
1. Go to U.S. Energy Information Administration’s, EIA, SEDS website, http://www.eia.gov/state/, scroll down and watch the five minute video on using the EIA pages. (on the right hand side)
2. Answer Essential Questions in your science notebook. Use the link above.
3. Have students share their observations with their closest partner and then discuss as a class.

EXPLORE

Student Grouping: Individual/Whole Group
Time: 20 minutes

Essential Questions
A. Are you surprised by the types of energy production in your state? Types that are present that you didn’t know about or types that make up a greater percentage of your states fuel diversity?
B. After your quick overview, is it clear to you whether your state provides most of its energy from renewable or nonrenewable sources? Explain.
C. Most energy within your state is produced from what source? Is it renewable or nonrenewable?

EXPLORE continued

Directions
1. Go to http://www.eia.gov/state/ and choose your state.
2. Take 10-15 min. to observe your map and associated legend, read your state’s “Quick Facts”, and the 5 tab graph toward the bottom. If you do not have access to a computer use the data sheets found on pages 6-4-6-7
3. Have students discuss responses to Essential Questions with a small group or whole class.

EXPLAIN

Student Grouping: Pairs/Individuals
Time: 25-45 minutes

Essential Questions
D. After making energy observations using the U.S. Energy Mapping System related to renewable and nonrenewable energy, what facts can be said about the types of energy we use in the U.S.?
E. According to you, how does this information affect you today and in the future?

Directions
1. Go back to or stay on EIA’s webpage – http://www.eia.gov/state/
2. Click on “U.S. Energy Mapping System” found on the right sidebar.
   a. Have students go to the layers tool and “Remove all layers”.
   b. Next have them explore all the renewable and nonrenewable energy sources, which can be expanded by clicking the “+” sign next to “All Power Plants”. Look at each resource one at a time, for example, click the “coal power plant” layer on the map, next take off the coal layer and look at natural gas, and so on.
3. Students will need to make observations about each layer and communicate them as a part of their Essential Questions in their science notebook.
ELABORATE

Student Groupings: Pairs/Individuals  
Time: 30-40 minutes

Essential Questions

F. What can you say in regards to “All Energy Consumption” and ‘Electric Only Consumption” for the state you are reviewing?

G. Looking at “Consumption by End Use”, how is the “appliances, electronics, and lighting” compare when you look at your state, the region, and the U.S.?

H. Take a moment and read over page two of the state fact sheet. i.e. housing types, number of televisions, programmable thermostats, etc. How can understanding this information transform into a better understanding of your school’s energy use and consumption?

I. What ideas do you have for reducing energy consumption at your school?

Directions

1. Back to EIA’s state pages -  
   http://www.eia.gov/state/, go to the right sidebar again, and this time click on “Household Energy Use > See state fact sheets”.

2. Have students skim this home page so they know what kind of information will be found on their state specific fact sheet. If you do not have access to a computer, Household Energy Use for Texas can be used and is found on page 6-8

3. You may like to approach this in one of two ways –
   a. Students work individually on their home state or state of choice
   b. Each student or pair of students is assigned a state

4. Have students answer Essential Questions. Then discuss in small groups or whole class discussion.

EVALUATE

Student Groupings: Individual  
Time: 20 minutes

Choose an evaluation tool or you may wish to allow students to choose which method of evaluation they would like to use in order to demonstrate mastery of this lesson.

1. Concept Quiz-found on page 6-9
2. Essay-found on page 6-11
3. Justified True/False-found on page 6-12

WEB REFERENCES

EIA’s SEDS  
http://www.eia.gov/state/seds/

EIA’s State Maps  
http://www.eia.gov/state/
The map above shows all of Louisiana’s natural resource power plants, refineries, and transmission lines. Within the state there are no solar or wind plants and two biomass plants. All other energy sources are produced from non-renewable resources.

### QUICK FACTS

- The Henry Hub in Erath, Louisiana, is the interconnect for nine interstate and four intrastate pipelines that provide access to major markets throughout the country; Henry Hub is used as the pricing point for natural gas futures trading on the New York Mercantile Exchange.
- With 19 operating refineries, Louisiana was second only to Texas as of January 2014 in both total and operating refinery capacity.
- The Louisiana Offshore Oil Port (LOOP) is the only port in the United States capable of offloading deep draft tankers.
- The U.S. Strategic Petroleum Reserve’s two Louisiana facilities consist of 20 salt caverns capable of holding almost 300 million barrels of crude oil.
- In 2012, Louisiana ranked third among the states in total energy consumption per capita, primarily because of the industrial sector, which includes many refineries and petrochemical plants.

_Last Updated: March 27, 2014_
LESSON 6: NATURALLY SPEAKING
Investigating Natural Resource Production in My State

### Louisiana Energy Production Estimates, 2013

- Coal
- Natural Gas - Marketed
- Crude Oil
- Nuclear Electric Power
- Biofuels
- Other Renewable Energy

**Source:** Energy Information Administration, State Energy Data System

### Louisiana Net Electricity Generation by Source, Apr. 2015

- Petroleum-Fired
- Natural Gas-Fired
- Coal-Fired
- Nuclear
- Hydroelectric
- Other Renewables

**Source:** Energy Information Administration, Electric Power Monthly
Louisiana Price Differences from U.S. Average, Most Recent Monthly

- Natural Gas - Citygate
- Natural Gas - Residential
- Electricity - Residential
- Electricity - Commercial
- Electricity - Industrial

Source: Energy Information Administration, Petroleum Marketing Monthly; Natural Gas Monthly; Electric Power Monthly
Household Energy Use in Texas
A closer look at residential energy consumption

All data from EIA’s 2009 Residential Energy Consumption Survey
www.eia.gov/consumption/residential/

- Texas households consume an average of 77 million Btu per year, about 14% less than the U.S. average.
- Average electricity consumption per Texas home is 26% higher than the national average, but similar to the amount used in neighboring states.
- The average annual electricity cost per Texas household is $1,801, among the highest in the nation, although similar to other warm weather states like Florida.
- Texas homes are typically newer, yet smaller in size, than homes in other parts of the country.

**ALL ENERGY average per household (excl. transportation)**

<table>
<thead>
<tr>
<th>Site Consumption</th>
<th>Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>million Btu</td>
<td>dollars</td>
</tr>
<tr>
<td>US</td>
<td>WSC</td>
</tr>
</tbody>
</table>

**ELECTRICITY ONLY average per household**

<table>
<thead>
<tr>
<th>Site Consumption</th>
<th>Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>kilowatthours</td>
<td>dollars</td>
</tr>
<tr>
<td>US</td>
<td>WSC</td>
</tr>
</tbody>
</table>

**CONSUMPTION BY END USE**

Compared to other areas of the United States, the warmer weather in Texas and its neighboring states means that air conditioning accounts for a greater portion of home energy use (18%), while space heating accounts for a much smaller portion (22%).

**MAIN HEATING FUEL USED**

Despite warmer weather than most other states, almost all Texas homes are heated. About half of Texas residents heat with electricity, a greater proportion than the U.S. average.

**COOLING EQUIPMENT USED**

Almost all Texas residents use air conditioning equipment, with over 80% using central air conditioners.
### About the Residential Energy Consumption Survey (RECS) Program

The RECS gathers energy characteristics through personal interviews from a nationwide sample of homes, and cost and consumption from energy suppliers.

The 2009 RECS is the thirteenth edition of the survey, which was first conducted in 1978.

Resultsing products include:
- Home energy characteristics
- Average consumption & cost
- Detailed energy end-use statistics
- Reports highlighting key findings
- Microdata file for in-depth analysis

www.eia.gov/consumption/residential/

---

### Housing Types

<table>
<thead>
<tr>
<th>Housing Type</th>
<th>US</th>
<th>WSC</th>
<th>TX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Homes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apartments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-Family Homes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Year of Construction

<table>
<thead>
<tr>
<th>Year of Construction</th>
<th>US</th>
<th>WSC</th>
<th>TX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1950</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1950-1969</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970-1989</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990-2009</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Average Square Footage

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Square Footage</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>1,971</td>
</tr>
<tr>
<td>WSC</td>
<td>1,717</td>
</tr>
<tr>
<td>TX</td>
<td>1,757</td>
</tr>
</tbody>
</table>

### No. of Televisions

<table>
<thead>
<tr>
<th>No. of Televisions</th>
<th>US</th>
<th>WSC</th>
<th>TX</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td></td>
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<td></td>
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<td>3</td>
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<td>4</td>
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<td></td>
</tr>
<tr>
<td>5+</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Have a DVR

<table>
<thead>
<tr>
<th>Have a DVR</th>
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<th>WSC</th>
<th>TX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### No. of Refrigerators

<table>
<thead>
<tr>
<th>No. of Refrigerators</th>
<th>US</th>
<th>WSC</th>
<th>TX</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2+</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

### Have a Separate Freezer

<table>
<thead>
<tr>
<th>Have a Separate Freezer</th>
<th>US</th>
<th>WSC</th>
<th>TX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Have Double/Triple Pane Windows

<table>
<thead>
<tr>
<th>Have Double/Triple Pane Windows</th>
<th>US</th>
<th>WSC</th>
<th>TX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Type of Clothes Washer

<table>
<thead>
<tr>
<th>Type of Clothes Washer</th>
<th>US</th>
<th>WSC</th>
<th>TX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Loading</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front Loading</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Car is Parked Within 20 Ft of Electrical Outlet

<table>
<thead>
<tr>
<th>Car is Parked Within 20 Ft of Electrical Outlet</th>
<th>US</th>
<th>WSC</th>
<th>TX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Car</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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More highlights from RECS on housing characteristics and energy-related features per household...

US = United States  | WSC = West South Central  | TX = Texas
Science Concept Quiz
Lesson 6: Naturally Speaking
Investigating Natural Resource Production in My State

Use the diagram to answer the following question.
Which statement can be validated using the information in the diagram above?
A. Major sources of geothermal energy can be found in states that surround the Great Lakes.
B. Hydro energy can only be utilized when directly pumped from the Pacific Ocean.
C. When compared to other regions of the U.S., the Great Plains region has several electric plants that supply energy through wind generation.
D. Power plants using wood energy can be found on the west coast of the U.S.

I. Answer
A. ☐ B. ☐ C. ☐ D. ☐

II. What is the main concept behind the question?
1. Renewable Energy
2. Experimental Design
3. Fossil Fuel Production
4. Reading Diagrams

III. Provide the reasoning for choosing your answer in part II.
IV. Why are the other responses in part I not the best answer choice?

A. 

B. 

C. 

D. 

Use the rest of this page if more room is needed to fully communicate your thoughts.
TEACHER ANSWER KEY

1. C

2. 4

3. Answers will vary. Even though the map is showing information regarding renewable resource potential in the U.S. the question isn’t testing renewable resource knowledge it is testing your ability to read and draw conclusions from a diagram.

4. Answers will vary.
   A. The diagram shows the states that surround the great lakes have great potential for wind and biomass technologies not geothermal.
   B. Hydro energy is found around the U.S., on all coasts and even in land locked states. Hydro energy doesn’t have to be drawn from ocean water but can be drawn from fresh and salt water sources alike.
   C. This is the correct answer. The central U.S., referred to as the Great Plains, shows there to be several wind power plants when compared to the east and west coastal regions.
   D. Power plants using wood energy cannot be found on the west coast but mainly in the southeastern U.S.
Application Essay

Your state uses several natural resources to provide residents, businesses, schools, and government with their energy needs. Summarize your state’s energy mix. Based on your state’s available resources what potential do you have to change your energy footprint?

What Is the Expectation?

- Use new lesson knowledge and statistical data to support your position
- Visual representations if applicable
- Key vocabulary
- Evidence of on grade level spelling and grammar usage
**Justified True or False Statements**

*Justified True or False Statements* provide a set of claims or statements that are examined by you. You are meant to draw on evidence from what you have learned to analyze the validity of the statements, and then describe the reasoning used to decide whether each claim is true or false.

*NOTE* Please use grade appropriate spelling and grammar.

<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>T</th>
<th>F</th>
<th>WHY I THINK SO…</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Each state relies solely on one type of fuel to support the state’s energy needs.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Reducing your energy consumption is one way to lower your energy footprint.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. There are states that have few or no natural resources to provide energy to their communities and therefore must rely on resources from other states to meet energy demands.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Use this space to include more evidence to support your claim and or to draw a model if applicable.
JUSTIFIED TRUE/FALSE GRADING RUBRIC
Assign a score of 0-3 based on the following criteria:
- Level 0 (17 pts.) = answered T or F correctly or incorrectly/no explanation
- Level 1 (23.3 pts.) = answered T or F correctly/cursory explanation
- Level 2 (28 pts.) = answered T or F correctly/deeper explanation
- Level 3 (33.3 pts.) = answered T or F correctly/complex explanation

TEACHER ANSWER KEY
Answers will vary.

1. False-Each state relies on a mix of fuels to meet the energy needs of its communities because no single fuel can provide for the demands of the entire state.

2. True-There are many ways to reduce your energy footprint. Since we know we can’t soley rely on renewable energy to meet our needs at this time one way we can lower our footprint is by reducing the amount of energy we use, such as choosing alternate forms of transportation, such as mass transit, walking, and cycling or buying local products to reduce fuel miles. I could also lower my hot water temperature setting or reduce the temperature on my thermostat.

3. True-Not every state has natural resources that can be acquired and must rely on other state’s resources to help meet their energy demands. States such as South Dakota and Iowa rely on coal received by rail from Wyoming to meet their coal needs.
LESSON 7: STIFLING, OPPRESSIVE, SWELTERING, OH MY!
The Science behind Heat Waves and their Effect on Human Health

GRADE LEVEL
11-12

TIME NEEDED FOR COMPLETION
3-4 class periods or 3-4 hours

STANDARDS
LA GLEs and NGSS alignments are found in the Appendix starting on page A-1

PREREQUISITE KNOWLEDGE
Links can be found under Web References unless noted below.
- What is Ozone?
- Radiation Spectrum

MATERIALS
- Science Notebook
- Guide 1: Collecting Monthly Surface Temperature Data, found on page 7-5
- Guide 2: Investigating Daily Variations in Temperature for Memphis, found on page 7-6
- Guide 3: Examining Ground Level Ozone Concentrations during 2007, found on page 7-8
- Computer with internet access – this lesson relies heavily on computer access and the ability to collect data from NASA servers. Please use the tip sheets included in this lesson to help you and your students utilize this tool.
- Color printer

ACADEMIC VOCABULARY
long-wave radiation, radiation spectrum, and meteorological observing station/weather station, proxy, flux, correlation, discrepancy

STUDENT OBJECTIVES
- Compare various temperature data sets over a series of years at a specific location and draw conclusions about their impacts.
- Using NASA data sets students will show that the Earth emits radiation at a rate that is proportional to its temperature.
- Explain the relationship between hot weather and large amounts of ground-level ozone.
- Describe the effects of heat waves on humans and draw conclusions on populations most vulnerable to those effects.

LESSON LINKS
Can be found under Web Reference unless noted below.
- Tech Tips found on page 15
- Special Report: Heat Wave August 2007, found in the appendix on page B-1.
- NWF Reports: Extreme Weather-Heat Waves, found in the appendix on page C-1

TEACHER BACKGROUND
Overview
In August 2007, a severe heat wave affected much of the central, southeast, and east parts of the United States. This lesson will give students an opportunity to explore how the heat wave progressed and learn about the impacts on human health. These sorts of heat waves are projected to become more frequent and more severe if climate change continues unabated, so can be thought of as an example of what to expect from climate change.

My NASA Data only includes monthly average temperatures. To explore the shorter term variations in temperature, we use daily observations of upward long-wave radiation from the surface. Because the Earth can be approximated as a black body, we can use the Stefan-Boltzmann equation to convert radiation to temperature. These calculations are done for students within the Excel spreadsheets, however if you would like for your students to work through some equations the equation is below.

\[ T = \frac{4 \phi}{\sigma} \]

WHERE:
- \( T \) = temperature in K
- \( \phi \) = energy flux density in W/m²
- \( \sigma \) = Stefan-Boltzmann constant = 5.67e-8 m² K⁻⁴

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Teacher Background continued

This conversion will give an approximation of average daily temperature because we are calculating it using only the integrated long-wave radiation. To be more accurate, we would use a value that integrates all the radiation (short- and long-wave) emitted by the surface. Even so, this approximation is reasonable because most of the radiation emitted by the Earth is in the long-wave part of the spectrum.

Extremely hot weather is often accompanied by high levels of the ground-level ozone pollution. This is because ozone is formed in the atmosphere by chemical reactions involving hydrocarbons and nitrogen oxides, pollutants from fossil fuel combustion. These chemical reactions are more efficient during hot and sunny conditions, exactly what is common during heat waves. The actual ozone concentrations will depend both on the meteorological conditions and on the pollution emissions.

Preparation

- Reserve computers and or computer lab time.
- Print a class set or enough for pairs of students to use, of Tech Tips for students to use as they collect data for any trouble shooting they may run into.
- Print a class set or enough for pairs of students to use, of each of the three data collection guides.

ENGAGE

Student Grouping: Whole Class/Small Groups
Time: 30-40 minutes

Essential Questions
A. Explain the impacts on humans during the heat wave of 2007.
B. Explain the agricultural impacts during the heat wave of 2007.
C. Why would fire dangers increase during a heat wave?

Directions
   a. Read introduction as a class
   b. Split class into 4 groups-assign each group one of the 4 remaining titles in the article, Human Impacts, Agricultural Impacts, Other Impacts, and Records.
   c. Each member of the group will read their section alone and then the group will assign a group member to speak to the class about the contents found within their section.
   d. Advise students to record important information in their science notebook.
2. Have a class discussion about the article.
3. Answer the Essential Questions.

EXPLORE

Student Groupings: Pairs
Time: 30 minutes

Essential Question
D. Why do you think the monthly average might not be a record breaker even though there were several record-breaking hot days in Memphis?
LESSON 7: STIFLING, OPPRESSIVE, SWELTERING, OH MY!
The Science behind Heat Waves and their Effect on Human Health

EXPLORE continued

Directions
1. Print out a class set for individuals or pairs of student to refer to during data collection, Guide to Collecting Monthly Surface Temperature Data, found on page 7-5.
2. Once students have collected data have them answer the Essential Question in their science notebook.

EXPLAIN

Student Groupings: Pairs
Time: 50-60 minutes

Essential Questions
E. What patterns do you notice in the radiation map? Are the patterns consistent with what you would expect based on the description of the summer 2007 heat wave? Explain.
F. The temperature conversion is an approximation. What factors are not accounted for?
G. Compare the average daily temperatures estimated from the LW satellite data to the surface observations of daily maximum temperatures. What are the similarities between the two datasets and what are the differences? How might you explain the differences?

ELABORATE

Student Groupings: Pairs
Time: 40-45 minutes

Essential Questions
H. What are the health impacts of exposure to extreme heat? To elevated ozone? What populations are especially vulnerable to ozone pollution and to the combined exposure to heat and ozone?
I. What is the relationship between ozone and temperature? What might explain the times when the two variables are well correlated and those times when they are not?

Directions
1. Print out a class set for individuals or pairs of student to refer to during data collection, Guide to Investigating Daily Variations in temperature for Memphis, found on page 7-6.
2. Once students have collected data have them answer the Essential Questions in their science notebook.
3. Homework-assess using the Reading Extensions Rubric. Urban Heat Island Effect via the EPA. Have students read opening page, Basic Information, Where You Live (Read and interact-looking at what is taking place in your state.), Heat Island Impacts, and Heat Island Mitigation, specifically, Benefits of Mitigation.
LESSON 7: STIFLING, OPPRESSIVE, SWELTERING, OH MY!
The Science behind Heat Waves and their Effect on Human Health

EVALUATE

Student Groupings: Individual
Time: 20-45 minutes depending on tool chosen

You may choose from the following assessment tools or allow your students to choose which tool will best demonstrate their knowledge.

1. Concept Quiz – found on page 7-9
2. Essay – found on page 7-12

Reading Extension – Provide students with the Reading Extensions Instructions found on page 13. Use the Article Summary Rubric to assess found on page 14.

- The Heat Wave of 2007
- Hansen et al: “Extreme heat waves…in Texas and Oklahoma in 2011 and Moscow in 2010 were 'caused' by global warming (Higher Level Reading)
- Heat Waves Could Become Common Place in the U.S.
- Climate Change Health Costs Add Up to One Big Bill

WEB REFERENCES

What is Ozone?
http://ozonewatch.gsfc.nasa.gov/facts/ozone.html

The Radiation Spectrum
http://imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html

Live Access Server
http://mynasadata.larc.nasa.gov/las/getUI.do


NWF Reports: Extreme Weather-Heat Waves

Urban Heat Island Effect
http://www.epa.gov/hiri/

READING EXTENSION ARTICLES

The Heat Wave of 2007
http://earthobservatory.nasa.gov/IOTD/view.php?id=7968

Hansen et al: “Extreme Heat Waves…in Texas and Oklahoma in 2011 and Moscow in 2010 were ‘caused’ by Global Warming”
http://thinkprogress.org/romm/2012/01/06/399350/hansen-extreme-heat-waves-texas-oklahoma-moscow-were-caused-by-global-warming/?mobile=nc

Heat Waves Could Become Common Place by 2039

Climate Change Health Costs Add Up to One Big Bill
http://www.onearth.org/article/climate-change-health-costs-big-bill
LESSON 7: STIFLING, OPPRESSIVE, SWELTERING, OH MY!
The Science behind Heat Waves and their Effect on Human Health

Guide to Collecting Monthly Surface Temperature Data

1. You will be looking at monthly surface temperature time series to see how temperatures during August 2007 compare to past Augusts. We will focus on Memphis, TN (latitude = 35°N, longitude = 90°W) because people in this city especially suffered, with 15 deaths attributed to the heat.
   b. Click on the Choose Dataset button. Then, choose Atmosphere > Atmospheric Temperature > Monthly Near-Surface Air Temperature (ISCCP).
      A map will be automatically generated.
   d. Enter the latitude and longitude for Memphis into the appropriate boxes just below the small grey map on the left of the screen.
   e. Set the time settings in Date Range to be Jan 1994 to Dec 2007.
   f. Click Update Plot and a time series plot will appear.
   g. Print out or save the graph. Refer to the Tech Tips if you need help.
   h. Answer Essential Questions.
Guide to Investigating Daily Variations in Temperature for Memphis

1. The My NASA Data archive does not include daily temperature data. As an alternative, we’ll use *daily surface all-sky long-wave upward flux*. The Earth emits radiation at a rate that is proportional to its temperature. Most of the radiation that the Earth emits is in the long-wave part of the radiation spectrum, making it a reasonable proxy for surface temperature. We’ll start by mapping the data for one of the days during the heat wave to see the pattern of long-wave radiation emissions across the United States.

   b. Click on the Choose Dataset button. Then, choose Atmospheric Radiation > Surface > Daily Surface All-sky LW Upward Flux (SRB). A time series chart will be automatically generated, but note that it may not be for the Memphis location.
   c. First let’s examine a map of this variable for the continental United States. Under “MAPS”, select Latitude-Longitude. Then, use the small map to select a box that includes the continental United States (click on the little rectangle to enable the dynamic selection of a plot area, □). Enter the date of August 11, 2007. Then click Update Plot. A map will be automatically generated.
   d. Print out or save the graph. Refer to the Tech Tips if you need help.

*All-sky longwave upward flux*- The amount of longwave energy (infrared or heat) leaving the top of the atmosphere under all-sky conditions (meaning the combination of clear and cloudy situations as they happen to occur). This parameter is available for daily, monthly, and 72-day averages, the latter from the older ERBE measurements.
2. Now, we will use the longwave radiation data to create a daily temperature time series for Memphis for the month of August 2007.
   a. Continuing from the last data collection point in part one, under “LINE PLOTS”, select *Time Series*.
   b. In the boxes under the small map, enter the latitude and longitude coordinates for Memphis, latitude = 35°N, longitude = 90°W. Select the date range of Aug 1, 2007 to Aug 31, 2007. Then click *Update Plot*. A graph will be automatically generated.
   c. We want to access the data used to create this plot, so that we can do our own calculations. Click the *Show Values* button and then click *OK* to accept the defaults. The data will appear in a second window.
   d. Follow the instructions in the *Tech Tips Guide* to import the data into the Microsoft Excel worksheet for this lesson. Put the raw data in the tab titled “Raw Data – LW Up”.
   e. Copy and paste the LW radiation data into the tab titled “LW_Temp_Ozone_Data” in the column labeled “LW Up All-sky radiation (W/m\(^2\))”.
   f. The radiation values will be automatically converted to temperature in degrees Fahrenheit (F), using the Stefan-Boltzmann equation provided in the *Background* section and the conversion from Kelvin to Fahrenheit (F).

3. Finally, we will compare the daily average temperature we estimated from the satellite observations of long-wave radiation to direct measurements of maximum daily temperature from a meteorological observing station located at the airport in Memphis.
   a. The spreadsheet tab for “LW_Temp_Ozone_Data”, includes a column labeled “TMAX (F) – Surface obs”. This data and the temperature computed from the longwave radiation observations have been automatically plotted onto a time series chart in the tab titled “Temp_LW chart”.

4. Take time to analyze the “Temp_LW chart”. Look for correlations. Look for discrepancies.

5. Answer the Essential Questions.
Guide to Examining Ground-Level Ozone Concentrations during 2007


2. Extremely hot weather is often accompanied by high levels of ground-level ozone pollution. We will examine to what extent this was the case in Memphis for the August 2007 heat wave. Notice that the “LW_Temp_Ozone_Data” tab of your spreadsheet also includes data for “Daily Ozone Maximum (ppb)”. These data are averaged from air quality observing stations located at 3 different sites in the greater Memphis area.

3. The ozone data has been plotted along with the two temperature measurements in the tab titled “LW_Temp_Ozone Time Series Chart”.

4. Take a moment and analyze the complete time series which includes temperature and ozone data. Look for correlations and discrepancies.

5. Answer the Essential Questions.
What conclusions can be drawn from the evidence in the line graph above?

A. As longwave temperature increases ozone also increases.
B. There is a direct relationship between on the ground daily maximum temperatures and satellite observing longwave temperatures.
C. Around August 15 ozone reached its maximum for the month while longwave temperature reached its minimum.
D. On the warmest day of August, ozone was at 90 ppb and longwave temperatures read around 85 degrees Fahrenheit.
I. Answer
A. ○ B. ○ C. ○ D. ○

II. What is the main concept behind the question?
1. Solar Radiation
2. Drawing Conclusions from Scientific Graphs
3. Making Accurate Measurements
4. Predicting Changes in Ozone

III. Provide the reasoning for choosing your answer in part II.

IV. Why are the other responses in part I not the best answer choice?
A. 
B. 
C. 
D. 

Use the rest of this page if more room is needed to fully communicate your thoughts.
TEACHER ANSWER KEY

1. D

2. 2

3. Answers may vary. The question asks one to draw a conclusion based on the information in the graph. You do not have to make measurements or understand ozone to answer the question correctly.

4. Answers may vary.
   A. The opposite occurs as longwave radiation increases ozone decreases.
   B. There is no direct relationship (inconsistent) between on the ground temperature maximums and longwave temperatures.
   C. Ozone did reach its maximum for the month of August 15th but longwave temperatures did not reach its minimum.
   D. Correct answer
LESSON 7: STIFLING, OPPRESSIVE, SWELTERING, OH MY!
The Science behind Heat Waves and their Effect on Human Health

Application Essay

Based on your analyses, collaborations, and writings provide evidence to convince your school board and district to take action to reduce the effects of heat waves on citizens.

What Is the Expectation?

Accurate science relating to heat waves and future predictions, as well as their effect on human health.

Visual representations if applicable

Key vocabulary

Evidence of on grade level spelling and grammar usage
LESSON 8: MASTER P IN THE HOUSE
Creating a School Action Plan to Address Energy and Climate Change

GRADE LEVEL
9-12

TIME NEEDED FOR COMPLETION
2-3 class periods or 1.5 hours with ongoing maintenance

STANDARDS
LA GLEs and NGSS alignments are found in the Appendix starting on page A-1

PREREQUISITE KNOWLEDGE
- Lessons 1-An Introduction to Eco-Schools USA
- Lesson 2-Conducting an Energy Audit
- At least 2 other lessons within the curriculum.

MATERIALS
- Science Notebook
- Computer with internet access
- Color printer (optional)

ACADEMIC VOCABULARY
Within student work you should see evidence of student attainment of academic vocabulary from throughout the entire curriculum. Be sure to encourage students to utilize their academic vocabulary and set the expectation that you will be looking for this evidence in their work.

STUDENT OBJECTIVES
- Perform an energy post-audit and summarize results to be presented school-wide via announcements, web presence, social media, etc.
- Create an energy and climate change, solutions-based action plan using knowledge gained from previous lessons and the conclusions drawn from the audits.
- Continue to incorporate the 7-Step Framework, including monitoring and evaluating progress toward reducing the school's carbon footprint and communicating with both the school and larger community.

LESSON LINKS
Can be found under Web Reference unless noted below.
- Classroom audit forms – use the saved pre energy audit forms from lesson 2 and complete the post audit columns.
- Classroom Carbon Calculator – complete the post audit and input the data in the carbon calculator students saved in lesson 2.
- School Tally Sheet - optional

TEACHER BACKGROUND
Overview
The United States is home to just 5 percent of the world’s population but consumes more than twenty percent of its energy. On average, a person in America uses ten times more energy than a person in China and nearly twenty times more than a person in India. U.S. energy needs are met primarily by non-renewable sources including gas, oil, and coal. Access to abundant and inexpensive energy contributes to our high standard of living, but burning large quantities of fossil fuels also has serious environmental and health consequences. These range from smog and acid rain to, most critically, the release of greenhouse gases leading to global climate change.

Why Should Schools Reduce Their Energy Use?
The nation's school districts spend more than $7.5 billion a year on energy. Schools are the largest energy consumer in many municipalities. But up to 30 percent of that energy is used inefficiently or unnecessarily. By implementing energy-conservation measures and using energy-efficient technologies, schools can significantly cut their energy use. The result is financial savings as well as a reduced environmental impact.

Continued on next page
LESSON 8: I’ve Got the Power
Investigating Solar and Wind Energy Potential at School

Teacher Background continued

Students will perform the post energy audit and report findings to audited classrooms. They will create a school report and share it with the campus. Students will analyze which energy tips proved to be the best energy conserving solutions. Once students know which variable worked the best, then students will work together to create a school wide plan. The plan will need to be approved by both the Eco-Action team and building administration.

Preparation:
- Assign students to the same classrooms they audited for the pre-survey.
- Review the Classroom Carbon Calculator

Helpful Hints:
The Audit Toolkit can be found at: http://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School/Cool-School-Challenge/Materials.aspx
You may want to utilize Audit Toolkit pages 21-25 and 27-30. Pages 21-25 have calculations information and pages 27-30 are worksheets that look exactly like the Excel spreadsheet in the event you want your students to work through the calculations as a part of a homework assignment.

ENGAGE

Student Grouping: Whole Class/Small Groups
Time: 20 minutes

Essential Questions
A. Where there appliances no longer in use or taken out of the classroom during your post survey audit that were in use or visible during your pre audit survey?
B. Do you feel these items make a difference in the overall footprint in the classroom?

Directions
1. Students will work together to review the pre-survey audit before performing the post survey audit.
2. Remind students of your expectations while auditing.
3. While performing the post survey audit students need to observe closely for new appliances and/or appliances no longer visible or in use.

EXPLORE

Student Groupings: Small Group
Time: 30-50 minutes

Essential Question
C. Did you notice any immediate changes within the classroom during your post survey audit? Explain.

Directions
1. Answer Essential Question after performing the audit.
2. Utilize the pre-audit survey to record the post audit survey data. Remember, working together the audit should take 4 students 8-10 min. per classroom.
EXPLAIN

Student Groupings: Whole Class/Small Group
Time: 60 minutes

Essential Questions
D. How does reducing a carbon footprint impact the Greenhouse Effect? Explain your thinking.
E. How does reducing a carbon footprint affect the greenhouse gas, CO₂? Explain your thinking.

Directions
1. Student groups will need to work together to input their collected data into the Cool School Challenge Carbon Calculator.
2. In their small groups work to answer the Essential Questions and then discuss as a whole group.

Tips
1. Remember there are 13 tabs within the Excel, but we will only utilize the following for this analysis:
   - Welcome
   - Electricity Info
   - Classroom Lighting
   - Energy Vampires, Other Appliances (optional), Heating, and Audit Summary
2. Students input data into orange boxes and the green boxes will automatically populate.
3. To scroll up and down within each spreadsheet use the up and down arrows. How you choose to have your students’ input data will depend on student ability. Please make sure you have looked over the Carbon Calculator before presenting to students. Here are a few options for inputting data:
   - Students working with their audit group
   - Teacher working with audit group
   - Volunteer working with audit group

ELABORATE

Student Groupings: Small Group
Time: 90 minutes

Essential Questions
F. Explain the advantages and disadvantages to completing the audit process, analysis, and evaluation as a part of a small group.

Directions
1. It’s time to create a final summary for the audited classrooms. To report fully, you will need to analyze the following documents:
   - CSC Classroom Lighting, Energy Vampires, Other Appliances, Heating, and Audit Summary – Print these final pieces out for easier analysis.
   - Copy of the Action Plan that was given to the audited classroom or posted in the common area.
   - The CSC Pledge for each audited classroom or common area.
2. To be supplied to the audited classroom.
   - Completed Audit Summary
3. After group has completed their analysis of all documents, they need to write up a summary to include:
   - A summary of the pre- and post-survey audit
   - Action plan tips that were successful and those that were not.
   - Recommendation for school wide energy conserving initiatives based on your group’s analysis.
4. Using the Cool School Challenge School Tally all students will work together to complete charts. As a class decide how to disseminate this information to the entire school.
EVALUATE

Student Groupings: Individual/Small Group
Time: 30 minutes

Allow students to use their science notebooks and other resources to fully explain and express their thoughts.

Students need to answer this question in an essay format:

Utilizing information learned from the auditing process along with previous lessons on climate change and energy, explain how Eco-Schools provides students with the knowledge and tools to make change. In your opinion, what has had the biggest impact on the school as a result of the awareness campaign about climate change and energy? What has had the biggest impact on you related to this campaign?

WEB REFERENCES

Cool School Challenge – CSC
All worksheets and tools are located at the following link. You will need to choose which grade band you used in Lesson 2.

Cool School Challenge – Audit Toolkit
Lesson 1: A Green Revolution – An Introduction to Eco-Schools USA

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**NGSS**

**HS-ESS3 Earth and Human Activity**

**Disciplinary Core Ideas, DCI**

ESS3.C Human Impacts on Earth Systems

ESS3.D Global Climate Change

**Science and Engineering Practices**

- Engaging in Argument from Evidence

**Crosscutting Concepts – Connections to Nature of Science**

Science Addresses Questions about the Natural and Material World

- Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2)
- Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2)
- Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2)

Lesson 2: Lights, Camera, Action: Conducting an Energy Audit

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Lesson 2 continued

NGSS

HS-ESS3 Earth and Human Activity

Disciplinary Core Ideas, DCI
- HS-ESS3.C: Human Impacts on Earth Systems
- HS-ESS3.D: Global Climate Change

Science and Engineering Practices
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence

Crosscutting Concepts
- Cause and Effect
- Systems and System Models
- Stability and Change

Lesson 3: This Blanket is Making Me Hot: Greenhouse Gas Investigations

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HS-ESS3 Earth and Human Activity

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- HS-ESS2.D Weather and Climate
- HS-ESS2.E Biogeology
- HS-ESS3.C: Human Impacts on Earth Systems
- HS-ESS3.D: Global Climate Change

Science and Engineering Practices
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Engaging in Argument from Evidence

Crosscutting Concepts
- Cause and Effect
- Energy and Matter
- Systems and System Models
- Stability and Change
Lesson 4: Why All the Wiggling on the Way Up? Investigating CO₂ Trends

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HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

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Lesson 4 Continued
HS-ESS2 Earth Systems

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HS-ESS3 Earth and Human Activity

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Lesson 5: Wherefore Art Thou, Albedo? Investigating Ice-Albedo Feedback

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## NGSS
### HS-PS3-Energy

#### Disciplinary Core Ideas, DCI
- PS3.A Definitions of Energy
- PS3.B Conservation of Energy and Energy Transfer
- PS3.D Energy in Chemical Processes

#### Science and Engineering Practices
- Developing and Using Models
- Using Mathematics and Computational Thinking

#### Crosscutting Concepts
- Energy and Matter

### HS-ESS2 Earth’s Systems

#### Disciplinary Core Ideas, DCI
- HS-ESS2.A: Earth Materials and Systems
- HS-ESS2.D Weather and Climate
- HS-ESS2.E Biogeology

#### Science and Engineering Practices
- Developing and Using Models
- Analyzing and Interpreting Data
- Scientific Knowledge is Based on Empirical Evidence (connection to *Nature of Science*)
- Engaging in Argument from Evidence

#### Crosscutting Concepts
- Cause and Effect
- Energy and Matter
- Stability and Change

### HS-ESS3 Earth and Human Activity

#### Disciplinary Core Ideas, DCI
- HS-ESS2.D Earth Weather and Climate
- HS-ESS3.C Human Impacts on Earth Systems
- HS-ESS3.D Global Climate Change

#### Science and Engineering Practices
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Engaging in Argument from Evidence
- Scientific Investigations Use a Variety of Methods (connection to *Nature of Science*)
- Scientific Knowledge is Based on Empirical Evidence (connection to *Nature of Science*)

#### Crosscutting Concepts
- Cause and Effect
- Systems and System Models
- Stability and Change
- Science Addresses Questions About the Natural and Material World (connection to *Nature of Science*)
### Lesson 6: Naturally Speaking: Investigating Natural Resource Production in My State

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### Lesson 7: Stifling, Oppressive, Sweltering, Oh My!
The Science behind Heat Waves and their Effect on Human Health

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<td>Energy in Earth's System</td>
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</tr>
<tr>
<td>Science and the Environment</td>
<td></td>
</tr>
<tr>
<td>Ecological Systems and Interactions</td>
<td>SE-H-A5, SE-H-A7</td>
</tr>
<tr>
<td>Science and the Environment</td>
<td></td>
</tr>
<tr>
<td>Environmental Awareness and Protection</td>
<td>SE-H-C2</td>
</tr>
</tbody>
</table>
### Lesson 7 continued

#### NGSS

**HS-PS3**

**Disciplinary Core Ideas, DCI**
- HS-PS3.B Conservation of Energy and Energy Transfer
- HS-PS3.D Energy in Chemical Processes

**Science and Engineering Practices**
- Developing and Using Models
- Using Mathematics and Computational Thinking

**Crosscutting Concepts**
- Cause and Effect
- Systems and System Models
- Energy and Matter

---

**HS-ESS2 Earth’s Systems**

**Disciplinary Core Ideas, DCI**
- HS-ESS2.D Weather and Climate
- HS-ESS2.E Biogeology

**Science and Engineering Practices**
- Developing and Using Models
- Analyzing and Interpreting Data
- Engaging in Argument from Evidence
- Scientific Knowledge is Based on Empirical Evidence (connection to *Nature of Science*

**Crosscutting Concepts**
- Cause and Effect
- Energy and Matter
- Structure and Function
- Stability and Change

---

**HS-ESS3 Earth and Human Activity**

**Disciplinary Core Ideas, DCI**
- HS-ESS2.D Weather and Climate
- HS-ESS3.B Natural Hazards
- HS-ESS3.C Human Impacts on Earth Systems
- HS-ESS3.D Global Climate Change

**Science and Engineering Practices**
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Engaging in Argument from Evidence
- Scientific Investigations Use a Variety of Methods (connection to *Nature of Science*)
- Scientific Knowledge is Based on Empirical Evidence (connection to *Nature of Science*)

**Crosscutting Concepts**
- Cause and Effect
- Systems and System Models
- Stability and Change
- Science Addresses Questions About the Natural and Material World (connection to *Nature of Science*)
Lesson 8: Master P in the House: Creating a School Action Plan to Address Energy and Climate Change

LA GLEs

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The Abilities Necessary to Do Scientific Inquiry</td>
<td></td>
</tr>
<tr>
<td>Environmental Science</td>
<td>SE-H-B5, SE-H-B6</td>
</tr>
<tr>
<td>Resources and Resource Management</td>
<td></td>
</tr>
<tr>
<td>Environmental Science</td>
<td>SE-H-C2</td>
</tr>
<tr>
<td>Environmental Awareness and Protection</td>
<td></td>
</tr>
<tr>
<td>Personal Choice and Responsible Actions</td>
<td></td>
</tr>
</tbody>
</table>

NGSS

HS-ESS3 Earth and Human Activity

Disciplinary Core Ideas, DCI

| HS-ESS3.C Human Impacts on Earth Systems |
| HS-ESS3.D Global Climate Change         |
| ETS1.B Developing Possible Solutions    |

Science and Engineering Practices

- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Scientific Investigations Use a Variety of Methods (connection to Nature of Science)
- Scientific Knowledge is Based on Empirical Evidence (connection to Nature of Science)

Crosscutting Concepts

- Cause and Effect
- Systems and System Models
- Stability and Change
- Influence of Science, Engineering, and Technology on Society and the Natural World (connections to Engineering, Technology, and Applications of Science)
- Science Addresses Questions About the Natural and Material World (connection to Nature of Science)

Appendix – Activity: Toil for Oil

LA GLEs

<table>
<thead>
<tr>
<th>Environmental Science Resources and Resource Management</th>
<th>SE-H-B1, SE-H-B6</th>
</tr>
</thead>
</table>
Toil for Oil Continued

NGSS

HS-ESS3 Earth and Human Activity

### Disciplinary Core Ideas, DCI
- HS-ESS3.A Natural Resources
- HS-ESS3.C Human Impacts on Earth Systems
- ETS1.B Developing Possible Solutions

### Science and Engineering Practices
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Scientific Investigations Use a Variety of Methods (connection to Nature of Science)
- Scientific Knowledge is Based on Empirical Evidence (connection to Nature of Science)

### Crosscutting Concepts
- Cause and Effect
- Systems and System Models
- Stability and Change
- Influence of Science, Engineering, and Technology on Society and the Natural World (connections to Engineering, Technology, and Applications of Science)
- Science Addresses Questions About the Natural and Material World (connection to Nature of Science)

---

Appendix – Activity: Measuring School Electronics

LA GLEs

<table>
<thead>
<tr>
<th>Environmental Science Resources and Resource Management</th>
<th>SE-H-B3, SE-H-B6</th>
</tr>
</thead>
</table>

NGSS

HS-ESS3 Earth and Human Activity

### Disciplinary Core Ideas, DCI
- HS-ESS3.A Natural Resources
- HS-ESS3.C Human Impacts on Earth Systems

### Science and Engineering Practices
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Scientific Investigations Use a Variety of Methods (connection to Nature of Science)
- Scientific Knowledge is Based on Empirical Evidence (connection to Nature of Science)

### Crosscutting Concepts
- Cause and Effect
- Systems and System Models
- Stability and Change
- Influence of Science, Engineering, and Technology on Society and the Natural World (connections to Engineering, Technology, and Applications of Science)
- Science Addresses Questions About the Natural and Material World (connection to Nature of Science)
### LEARNING OBJECTIVES
- To investigate energy use within the school and identify inefficiencies.
- To record and analyze energy data.
- To implement student based solutions to improve energy efficiency.

### CURRICULUM LINKS
Mathematics, Science, Citizenship, Language Arts

### ECO-SCHOOLS USA PATHWAYS
Energy, Climate Change, Consumption and Waste

### PROCEDURE
1. The Eco-Action team should work together to gather the data needed to complete the audit form. (Note: If you have completed the climate change audit you will have already gathered some of this data)
2. Complete the entire audit form. You may need the assistance of your school facility manager or building engineer to answer some of the questions or help you conduct the audit.
3. Open the carbon calculator and input information into the ‘Electricity Info’ tab. You can use the national average or research information for your local utility. Instructions for completing this are provided on the tab. [http://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School/Pathways/Energy/Audit.aspx](http://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School/Pathways/Energy/Audit.aspx)
4. Next, input data from the audit form into the following tabs in the spreadsheet: Classroom Lighting, Energy Vampire, Other Appliances, and Heating.
5. Go to the Add it Up tab to calculate the carbon footprint of each participating classroom based on energy usage. (NOTE: This carbon data, along with the other information you have gathered through the auditing process will provide a complete picture of your energy use.)
PROCEDURE continued

6. Next, open the school tally form, and input data from each classroom to calculate your school’s overall carbon footprint.
   
   http://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School/Pathways/Energy/Audit.aspx

7. Analyze the results and report the findings from the audit sheet and carbon calculator to the school community.

8. Formulate an action plan.

9. **At a later point complete the audit** again to help monitor and evaluate your progress. You will be able to compare your new and old data to calculate how much your school has reduced its energy use.

10. Keep this audit form, the carbon calculator, and the school tally form with your records. This information will be needed when responding to periodic Eco-Schools USA surveys, when applying for awards, and when communicating with the community and members of the media.

Helpful Tips

- Review the audit form first before sharing it with your students. You will need to determine the best way to gather the data.
- For the first part of the audit you will collect data at the classroom level. For the second part of the audit you will be answering questions about your school campus overall.
- Tables with asterisks (*) in the header indicate that data gathered needs to be transferred to the carbon calculator.
### CLASSROOM DATA COLLECTION

**Teacher:** ___________________________  **Classroom #:** _______  **Subject:** ___________________________

### CLASSROOM EVALUATION

<table>
<thead>
<tr>
<th></th>
<th>Before Taking Action</th>
<th>After Taking Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>We found the room to be: <em>(circle only if applies)</em></td>
<td>Hot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cold</td>
</tr>
<tr>
<td></td>
<td>We believe this is due to: <em>(circle all that apply)</em></td>
<td>Temperature Settings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Doors and/or windows open or leaking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blinds not closed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other:________________</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other:________________</td>
</tr>
<tr>
<td>2.</td>
<td>We found dripping faucets or faucets left on.</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>

**NOTES:**

---

ECO-SCHOOLS USA ENERGY AUDIT
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## CLASSROOM LIGHTING*

<table>
<thead>
<tr>
<th>Switch</th>
<th>How many bulbs per switch?</th>
<th>Watts per bulb</th>
<th># hours per day the switch is on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before Taking Action</td>
<td>After Taking Action</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
# CLASSROOM ENERGY VAMPIRES*

<table>
<thead>
<tr>
<th>Electronic Device</th>
<th>How Many?</th>
<th>“Active” (on and performing main function)</th>
<th>“Sleep/Standby” (on, ready-for-action but not in use)</th>
<th>“Off” (turned off, but still plugged in)</th>
<th>“Power strip” (Plugged into power strip, which is turned off at end of day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop Computer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laptop Computer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Monitor – Conventional (CRT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Monitor – Flat Screen (LCD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi-Function Printer/Scanner/Copier</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stereo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Television</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DVD/VCR Player</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMART Board</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCD Projector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*ECO-SCHOOLS USA ENERGY AUDIT*  
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## ELECTRICITY – OTHER APPLIANCES IN THE CLASSROOM* (Optional)

<table>
<thead>
<tr>
<th>Electronic Device</th>
<th>How Many?</th>
<th>Wattage</th>
<th>Hours On Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Before Taking Action</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Fill in other appliances such as: microwaves, refrigerators, electric pencil sharpeners, lamps, etc.)

**NOTES:**
### CLASSROOM HEATING*

<table>
<thead>
<tr>
<th>Category</th>
<th>Before Taking Action</th>
<th>After Taking Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Is there a controllable thermostat in the classroom, main office, or at the district level?</td>
<td>□ Yes □ No</td>
<td>□ Yes □ No</td>
</tr>
<tr>
<td>2. If so, to what temperature is it set?</td>
<td>____ warm weather</td>
<td>____ warm weather</td>
</tr>
<tr>
<td></td>
<td>____ cold weather</td>
<td>____ cold weather</td>
</tr>
<tr>
<td>3. Do you try to keep your classroom's windows or doors shut in the winter?</td>
<td>□ Yes □ No</td>
<td>□ Yes □ No</td>
</tr>
<tr>
<td>4. How is your school heated?</td>
<td>____ electricity</td>
<td>____ electricity</td>
</tr>
<tr>
<td></td>
<td>____ fuel oil</td>
<td>____ fuel oil</td>
</tr>
<tr>
<td></td>
<td>____ natural gas</td>
<td>____ natural gas</td>
</tr>
</tbody>
</table>

**NOTES:**
### School Data Collection

Name of School: __________________________________________
Student Population: __________
Building Age: __________

### Building Envelope

<table>
<thead>
<tr>
<th>Before Taking Action</th>
<th>After Taking Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilowatt Hrs.</td>
<td>Kilowatt Hrs.</td>
</tr>
</tbody>
</table>

1. Looking at your school’s electricity bill:
   - How much electricity did your school use last month? $______________
   - How much money did your school spend on electricity last month? $______________

2. Looking at exterior windows:
   - Are any of them cracked or leaking? □ Yes □ No
   - Are the seals between the frame and pane tight? □ Yes □ No

3. Do outlets on exterior walls have insulated outlet gaskets? □ Yes □ No

4. Are the seals around exterior doors and door frames tight? □ Yes □ No

5. Do you notice visible cracks in the building’s foundation? □ Yes □ No

### Notes:

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<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What fuel source provides heating for the building?</td>
<td>☐ Natural Gas, ☐ Electric, ☐ Propane, ☐ Solar, ☐ Wind Power, ☐ Biofuel, ☐ Coal, ☐ Other:_________</td>
</tr>
<tr>
<td>2. What equipment is used to deliver that heating?</td>
<td>☐ Hot Water Boiler, ☐ Steam Boiler, ☐ Forced Air Furnace, ☐ Other:_________</td>
</tr>
<tr>
<td>3. Age of equipment?</td>
<td></td>
</tr>
<tr>
<td>4. If boiler, are pipes insulated?</td>
<td>☐ Yes ☐ No</td>
</tr>
<tr>
<td>5. If the building has ducts, are they insulated and sealed?</td>
<td>☐ Yes ☐ No</td>
</tr>
<tr>
<td>6. What type of equipment is used to cool the building?</td>
<td>☐ Window Air Conditioners, ☐ Central Air Conditioner, ☐ Chiller, ☐ Geothermal</td>
</tr>
</tbody>
</table>
NOTES

SUMMARY

* After completing the questions above, input classroom data from tables with asterisks into the carbon calculator. After all of the classroom data has been entered into the calculator, review your Add it up! Audit Summary. Once all participating classrooms have completed the audit, calculate your school’s overall carbon footprint using the school tally form. The carbon calculator and school tally form will need to accompany this audit when submitting your application for an award.

Energy auditing documents are partially adapted from materials provided by Educational Dividends. Educational Dividends developed the curriculum for Student Power and the award-winning EnergyNet Project (www.energynet.net). Educational Dividends also manages the EnergyNet Project. As well, some of our energy auditing documents were partially adapted from materials provided by the Puget Sound Clean Air Agency as part of their Cool School Challenge. The Cool School Challenge program was acquired by the National Wildlife Federation in 2012 and incorporated into our Eco-Schools USA program.
August 2007 Heat Wave

National Oceanic and Atmospheric Administration

National Climatic Data Center

Note: Data in this report are compiled from preliminary statistics
Updated 31 August 2007

Overview

August 5-20 Maximum Temperature Departures

A severe heat wave occurred across much of the central, southeast, and eastern parts of the Southern U.S. throughout much of August 2007. The impacts of this heat wave are still being assessed as above-normal temperatures persist across much of the Southeast. More than 50 deaths have been attributed to the excessive heat. Numerous all-time record highs were set in August, along with scores of new daily high temperatures. Average temperatures during the warmest periods from the 7th—11th and again from the 15th—17th were more than 10°F warmer than average in many parts of the country. Preliminary calculations indicate that the nationally averaged temperature during August will likely make this one of the top 20 warmest Augusts for the United States since 1895.
Although August is typically one of the hottest months of the year, several factors enhanced the severity of this heat wave. A dominant ridge of high pressure persisted stable across the south, central and southeast regions for much of the month, prohibiting the jet stream from progressing southward and other low-pressure systems from moving eastward. The heat was also exacerbated by persistent and intensifying levels of severe to exceptional drought across much of the Southeast, which began early this year. Also exacerbating the impacts of the heat and drought conditions was the devastating April Freeze that killed off many early-budding plants and crops. The persistent drought and heat wave have further decreased soil moisture to below 98-99% of normal levels.

### Human Impacts

#### Number of Days 100°F or Greater

The persistent much above normal temperatures experienced across much of the central and southeastern U.S. have been blamed for at least fifty-one deaths this month as of August 27,
2007 (AP). The highest human toll came in the state of Tennessee, which lost 15 people to the heat, 14 in the Memphis area alone. Alabama reported 12 fatalities to the heat, Missouri lost 9, and Arkansas and Georgia each had 4 fatalities. Three deaths in Illinois were attributed to the heat and 2 people in South Carolina died due to heat-related injuries. One person in Mississippi died due to the excessive and prolonged high temperatures. Not included in the above statistics were reports of at least two small children who perished when left in cars during this heat wave: one near St. Louis and one east of Cincinnati. Several other people are suspected to have perished from heat-related causes.

In addition to the numerous deaths attributed to the heat wave, innumerable heat-related illnesses have been reported in many parts of the region. Heat exhaustion has plagued everyone from teenage athletes to construction workers to those attending activities in honor of Elvis in Memphis on August 16 (AP). Prolonged exposure to high temperatures poses an especially dangerous problem for elderly, children, and low-income residents without adequate air conditioning. Many cities and/or aid organizations provided free or low-cost fans, air conditioners, cool stations, bottled water, and vouchers for electric bills in order to assist those in need. Additionally, many schools without air conditioning dismissed students early or cancelled afternoon classes during the past few weeks.

Agricultural Impacts

The combination of the exceptional drought and the prolonged heat wave has taken a heavy toll on the agriculture industry across the Southeast. Many crops have been severely damaged from a combination of excessive heat and prolonged dry or drought conditions in the central, southeast, and eastern parts of the Southern U.S. Soil moisture values are extremely low across much of the central and southeastern U.S. The USDA reported that 81 percent of the Alabama corn crop is in poor or very poor condition as of August 23 and the corn crop in many parts of Tennessee is forecast to be a total loss. As of August 23, 2007, between 40% and 52% of pasture and rangeland in Alabama, North Carolina, and Tennessee was listed as being in "very poor" condition. Many herd owners have been forced to sell some of their livestock due to a lack of
water and vegetation and the escalating costs of food due to the effects of the heat wave and drought (AP).

Other Impacts

![Average Streamflow during August 1-27, 2007](image)

Fire danger increases significantly during extremely hot and dry periods, and many areas in the Central and Southeastern U.S. were under a burn ban in late August. The State of Tennessee has implemented [burning permit requirements](#) six weeks earlier than usual.

The hydrologic impacts of the heat wave and drought include exceptionally low water levels in many streams and rivers, several of which have set new record low flow levels, and water table levels significantly below normal. Consequently, many areas are now under voluntary or mandatory water restrictions.
Records

Daily and All-Time Records Summary for August 2007

As of August 29, 13 new all-time record high maximum temperature records were established and 26 were tied. Additionally, 28 new all-time record high minimum temperature records were established and 34 were tied. No new all-time record low maximum or minimum temperatures were established.

Several hundred new daily high maximum temperature records were set in the first half of August. Unlike the previous brief heat wave in the early part of July in the Northwest U.S., the heat wave in the central and southeastern parts of the U.S. continued for several weeks and covered a larger area. There were more than a hundred daily maximum temperature records matched or broken every day for eleven straight days from August 7—17.

These warm temperatures persisted throughout the nighttime in many areas, and hundreds of new daily high minimum temperature records were established. Nearly 400 new records were established or matched on August 8, 2007.

• August 2007 all-time record highest maximum temperature records
• August 2007 all-time record highest minimum temperature records
• August 2007 daily highest maximum temperature records.
• August 2007 daily highest minimum temperature records

NOTE: These records are based on the historical daily observations archived in NCDC's Cooperative Summary of the Day data set and preliminary reports from Cooperative Observers and First Order National Weather Service stations. The preliminary data and these records are subject to change.
**Drought**

More information on the drought affecting much of the United States can be found at the [Federal U.S. Drought Monitor](https://droughtmonitor.unl.edu/), or at [NCDC's U.S. Drought page](https://www.ncdc.noaa.gov/) after September 13.

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**Citing the Article**

National Climatic Data Center; “August 2007 Heat Wave”; August 2007; NOAA’s National Climatic Data Center, Asheville, NC
Many Americans in the eastern and southern United States have been sweltering during summer 2010.

As global temperature records have been set for the early summer months, states and cities are also setting hundreds of temperature records. More than 70 million Americans experienced extreme heat during June and July.

Unfortunately, climate models indicate that an average summer in 2050 will have even more days topping 90°F if global warming continues unabated. For example, Washington, DC is on track to have about 50 days of 90°F or hotter weather in summer 2010. By midcentury, an average summer could have 55 to 100 such days, depending on how much we curb global warming pollution.

This supplement to National Wildlife Federation’s 2009 report More Extreme Heat Waves: Global Warming’s Wake-Up Call examines just how hot summer 2010 is shaping up to be and the implications for air pollution, health, and the economy.
RECORD SETTING GLOBAL TEMPERATURES

According to the National Oceanic and Atmospheric Administration (NOAA), 2010 brought the hottest June on record. Almost the entire global land surface experienced warmer-than-normal conditions, with especially high temperatures in the eastern and south-central United States. The warm summer continued the heat we already experienced through the first half of 2010, which is the hottest January through June on record.¹

2010 U.S. TEMPERATURES IN THE RECORD BOOKS

In 2010, New Jersey, Delaware, and North Carolina had their hottest June on record, while Rhode Island and Delaware had their hottest July. Sixteen other states had Junes or Julys that ranked in the top-five hottest.² That means upward of 70 million Americans experienced extreme heat these two months. Hundreds of daily temperature records were broken across the country.

Not surprisingly, this hot spell has brought many days where the thermometer topped 90°F. Our analysis of large cities in the eastern United States shows that most locations have had about twice as many days with temperatures exceeding 90°F than they typically would by the end of July. For example, Washington, DC, had 39 days with temperatures in the 90s by July 31, 2010, compared to 18 days for the same period in an average year. If conditions continue to stay warm, or even if we return to more average conditions in August, Washington and several other cities are on track to meet or break records for the total number of days exceeding 90°F in a single year. Cities in the south-central United States are also running hot: many have had about 50 percent more days over 90°F than average.

STATES FEELING THE HEAT IN 2010

SOURCE: National Oceanic and Atmospheric Administration

<table>
<thead>
<tr>
<th></th>
<th>June</th>
<th>July</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hottest on Record</td>
<td>New Jersey Delaware N. Carolina</td>
<td>Rhode Island Delaware</td>
</tr>
<tr>
<td>Second Hottest on Record</td>
<td>Maryland Virginia S. Carolina Florida Louisiana</td>
<td>New Jersey</td>
</tr>
<tr>
<td>Third Hottest on Record</td>
<td>New Hampshire Massachusetts Florida</td>
<td></td>
</tr>
<tr>
<td>Fourth Hottest on Record</td>
<td>Rhode Island Kentucky Tennessee Alabama</td>
<td>Maine Connecticut N. Carolina</td>
</tr>
<tr>
<td>Fifth Hottest on Record</td>
<td>W. Virginia Georgia Mississippi Arkansas</td>
<td>Virginia</td>
</tr>
</tbody>
</table>

SOURCE: National Oceanic and Atmospheric Administration
Number of days at Ronald Reagan National Airport, just outside Washington, DC, when temperature were 90°F or greater. Shaded area shows the average number for 1950-2009. Solid line shows the number for 2010. Dashed line is the number expected if August and September follow the past average. Data source: National Oceanic and Atmospheric Administration Global Historical Climatology Network (http://lwf.ncdc.noaa.gov/oa/climate/ghcn-daily/).

Number of days when average ozone measured at three locations in the Washington, DC, metropolitan area exceeded 65 parts per billion (ppb). Shaded area shows the average number for 2005-2009. Solid line shows the number for 2010. Dashed line is the number expected if August and September follow the past average. Data source: U.S. Environmental Protection Agency AirExplorer (http://www.epa.gov/mxplorer/index.htm).
Extrreme summer 2010 heat could be typical by midcentury

Summers like the current one, or even worse, will become the norm by 2050 if global warming pollution continues to increase unabated. Alternatively, taking steps to reduce emissions can help avoid some of this increase in extremely hot days. For example:

- Washington, DC, is projected to have about 55 days over 90°F by midcentury under a lower-emissions scenario and about 100 such days if emissions are higher. For comparison, the city will likely have about 50 days above 90°F in 2010 if August and September have an average number of very hot days.

- Philadelphia, PA, is projected to have about 40 days over 90°F by midcentury under a lower-emissions scenario and about 60 such days if emissions are higher. Through the end of July, the city had 25 days exceeding 90°F in 2010 and is on track to have about 30 or more such days for the year.

- St. Louis, MO, is projected to have about 60 days over 90°F by midcentury under a lower-emissions scenario and about 80 such days if emissions are higher. This year, the city is on track to have 45 extremely hot days, about 10 more than average.

The takeaway message is that, for each of these cities and for countless others that have been sweltering the last couple months, summer 2010 could be considered mild compared to the typical summers of the future.

The climate projections for the end of the century are even more dramatic (see maps). Much of the country will have twice as many days over 90°F if emissions are not curbed. That means much of the southern United States will have at least three or four months each year with temperatures in the 90s or above.
EXTREME HEAT CONDUCIVE TO BAD AIR QUALITY

Hot and sunny days with relatively stagnant winds provide textbook conditions for building up unhealthy levels of ground-level ozone pollution. The steamy summer of 2010 has brought many such days, despite continued efforts by the U.S. Environmental Protection Agency and individual states to restrict emissions from tailpipes, power plants, and industry.

For example, by the end of June 2010, the Washington, DC, metropolitan area had 18 days when maximum 8-hour average ozone met or exceeded 65 ppb, about 50 percent more than the region typically has by that time based on the previous 5 years of data.

Continued global warming could make it even more difficult to meet the ground-level ozone standards in the future. Warmer conditions and more periods with clear, sunny weather patterns would be conducive to ozone formation. At the same time, some emissions of ozone precursors are expected to increase as the demand for air conditioning and the risk of wildfires increase.

One study found that global warming could increase the ground-level ozone by 10 ppb or more during heat waves by 2050 in the Midwest and Northeast. For a city like Washington, DC, that means about 42 excess deaths for each day that there is elevated ozone. These would be in addition to any deaths caused primarily by exposure to extreme heat.

In January 2010, the Obama Administration announced its intention to lower the ozone standard from 75 parts per billion (ppb) to something in the range of 60 to 70 ppb. EPA estimates that lowering the standard to 65 ppb would to save 1740 to 5100 lives annually, prevent nearly a million missed school days each year, and provide a total benefit to the economy of $15 to $43 billion by 2020. Stricter controls on ozone precursors likely would have co-benefits of reducing emissions of carbon dioxide and other greenhouse gases.

SOURCES

1. National Oceanic and Atmospheric Administration (NOAA), 2010: June, April to June, and Year-to-Date Global Temperatures were Warmest on Record. Available at: http://www.noaanews.noaa.gov/stories2010/20100715_globalstats.html (Accessed July 20, 2010).

Report prepared by:
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Special thanks to Katharine Hayhoe, Texas Technical University, for providing downscaled climate projections for Washington, DC.

Report design by:
Max Greenberg

THIS REPORT, CHARTS FOR ADDITIONAL CITIES, AND OTHER REPORTS IN NWF’S SERIES ON GLOBAL WARMING AND EXTREME WEATHER ARE AVAILABLE AT WWW.NWF.ORG/EXTREMEWEATHER
TOIL FOR OIL
Fossil Fuel Extraction Activity

GRADE LEVEL
6-12

ESTIMATED TIME NEEDED
45-60 minutes

STANDARDS
LA GLEs and NGSS alignments are found in the Appendix starting on page A-1

MATERIALS
- Science notebook
- Computer with internet access
- 2 pounds of dried red beans for a class of 25 or fewer (this is for 2 groups so double it if you want 4 groups)
- 2/3 cup of dried black beans for a class of 25 or fewer (this is for 2 groups so double it if you want 4 groups)
- 2 medium sized plastic bowls (this is for 2 groups so double it if you want 4 groups)
- Timer
- Oil Extraction Data Sheet

STUDENT OBJECTIVES
- Create a fossil fuel extraction company and develop a plan for the extraction of oil at your site for 3 years.
- Simulate extracting oil from the ground and collect oil data and methods of extraction used.
- Design a tool that will increase production and decrease waste.
- Debate the social, environmental, and economic impacts of using a nonrenewable resource.
- Identify clean, renewable, and sustainable energy sources.

OVERVIEW
In this oil extraction simulation, students experience the increasing difficulty of extracting a limited, nonrenewable resource over several years. Students consider and discuss renewable energy sources.

PREPARATION
Determine the number of groups you will have; between 2 and 4 work best. In each bowl place 2 cups of red beans and 1 cup of black beans. You can modify this as you fit. Use different size bowls if possible to simulate oil company’s location differences. Read through the directions carefully and set safety expectations before beginning.

ESSENTIAL QUESTIONS
A. What happened to the oil production as the number of oil drillers increased with each year? What might this simulate?
B. With each year, was it easier or harder to extract the oil?
C. How is this activity similar to the extraction of real nonrenewable oil reserves?
D. How is the use of a nonrenewable resource different from the use of a renewable resource?
E. What happens to a resources when you have infinite population growth and a finite resource?
EXPECTATIONS
- NO RUNNING
- Each company will send 4 representatives the first year and they will gather around the bowl filled with the mixed beans. DO NOT TOUCH BEANS YET! The remaining students will wait while the year 1 students extract the oil.
- Give students 30 seconds to extract the oil by picking out the black beans from the bowl and leaving the red beans in the bowl.
- At the end of 30 second period, have students stop extracting, count their barrels of oil, and one representative will record their extraction numbers in their science notebook, along with the method used to extract. Each black bean is equal to 1 barrel of oil. DO NOT PUT ANY BEANS BACK IN THE BOWL.
- Have the same 4 students, plus three more representing year 2 oil drillers gather around the bowls and repeat the activity for 30 more seconds. Have each company again report their totals in their science notebook and on the class chart.
- Repeat this process for year 3.

DIRECTIONS
1. Tell the class that today they are going to “drill” for oil, a nonrenewable resource, and they will simulate the extraction of oil over 3 years. If you include designing a tool for extraction that will take 6 years. You will want to add time to the overall plan to allow for construction, testing, redesign, and more testing.
2. Divide class into 2 to 4 groups. Each group will need to come up with a name for their energy company along with the method(s) they will use to extract oil from their bowl. Provide only 5 minutes for this quick brainstorming and decision making. As they are creating their businesses, create a class chart that will hold each company name and their associated total barrels extracted for each year.
3. One student in the company will need to be the record keeper. They will record methods used to extract oil and total amounts of oil extracted. This data will be used to fill in the data sheet. The data sheet will not be passed out until after the simulation is complete.
4. In year one – do not provide many rules, details, or instructions. This will bring about debate, in fairness, ethical business standards, environmental safety, etc. Starting in year 2 you can provide them with more details and instructions. Everyone will now be working under the same rules.
5. In year 3 you may want to make a change or two to simulate a change in environmental protection laws.
6. After year 3, all students in the group will need to fill out the Oil Extraction Data Sheet and answer the Essential Questions.
7. OPTIONAL: If time permits you can now allow students to design a solution to decrease waste and environmental pollution from their associated with their extraction methods. Provide students with materials to design a tool/technology that will help boost their environmental safety record. Allow students enough time to design, create, test, and go back to the drawing board a couple of times before running through the three year simulation again. This time through, all three years, companies will work under the same rules and regulations.
8. Ask each student to summarize the impact their tool/technology had on the extraction process and include a comparison against year’s 1-3. How likely does a simulation like this occur in the real world? What are the benefits and drawbacks to these processes in the real world?
TOIL FOR OIL
Fossil Fuel Extraction Activity
E-3

Oil Extraction Data Sheet

Student Name: ____________________________________________________________

Oil Company: ___________________________________________________________

Keep track of your oil company’s total barrel extraction. Each black bean is equal to 1 barrel of oil.

<table>
<thead>
<tr>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total from all oil drillers in your company</td>
<td>Total from all oil drillers in your company</td>
</tr>
<tr>
<td>BARRELS OF OIL EXTRACTED</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. How many drillers did your company have in year 1? _____ in year 2? _____ in year 3? _____

2. In which year was the largest number of barrels extracted? _____________________________________

3. In which year was the second largest number barrels extracted? ________________________________

4. Which year had the least number of barrels extracted? Why? _____________________________________

5. How does this activity simulate real oil extraction?

_____________________________________________________________________________________

6. Explain the difference between nonrenewable and renewable sources of energy.

_____________________________________________________________________________________

7. List 5 things you can do personally to conserve energy?

_____________________________________________________________________________________

8. List 3 policies, laws, manufacturing practices, or other types of legislation that could be implemented to reduce dependency on nonrenewable energy sources.

_____________________________________________________________________________________

_____________________________________________________________________________________

_____________________________________________________________________________________
GRADE LEVEL
6-12

TIME NEEDED FOR COMPLETION
2 class periods or 1.5-2 hours

STANDARDS
LA GLEs and NGSS alignments are found in the Appendix starting on page A-1

MATERIALS
- 6 energy monitoring devices. Note: These can be obtained from a variety of sources, i.e. local hardware stores, internet -- average cost is $29.99; available from multiple vendors, such as Belkin or Amazon. Recommended: Belkin Conserve Insight Energy Use Monitor.
- 6 different power-using devices -- i.e. fan, laptop, microwave, refrigerator, and cell phone, computer, printer, pencil sharpener, etc.
- Worksheet table for each student with columns for: Device, Watts on, Cost On, Watts Off, Cost Off. A worksheet template is provided that can be used for this lesson plan.

TEACHER BACKGROUND
The United States is home to just 5 percent of the world’s population but consumes more than 20 percent of its energy. On average, a person in the United States uses 10 times more energy than a person in China and nearly 20 times more than a person in India.

U.S. energy needs are met primarily by non-renewable sources including, gas, oil, and coal. Access to seemingly, abundant and inexpensive energy contributes to our high standard of living, but burning large quantities of fossil fuels also has serious environmental and health consequences. These range from smog and acid rain to, most critically, the release of greenhouse gases leading to global climate change.

The nation’s school districts spend more than $7.5 billion a year on energy. Schools are the largest energy consumers in many municipalities. Up to 30 percent of that energy is used inefficiently or unnecessarily. By implementing energy-conservation measures and using energy-efficient technologies, schools can significantly cut their energy use. The result is financial savings as well as a reduced environmental impact.

INSTRUCTIONS
1. Find out what students know. Use a teaching strategy to dialogue with students about electricity, energy, energy saving. Have it displayed for the class to see throughout this activity.
2. Set up 6 stations with the information on the following pages. Look through each station to see what if any materials are needed, such as a computer.
3. Students will need to bring their science notebook and Measuring Electricity Activity worksheet with them to each station.
4. Some stations will just be information. They should take notes as they may need some of the information to help them answer questions.
STATION 1: WHERE DOES ELECTRICITY COME FROM?

Power plants make electricity out of other forms of energy. Most electricity in the U.S. today comes from converting the heat energy released from burning fossil fuels--coal, natural gas and oil. The rest is generated from nuclear reactors and from renewable sources, such as sunlight, wind, falling water and geothermal heat.

In a typical power plant, a primary energy source like coal is burned to create heat, which is converted in a boiler to mechanical energy in the form of superheated, high-pressure steam. The steam is directed into a turbine, where it pushes on blades attached to a central shaft or rotor. The rapidly spinning rotor powers a generator.

For an excellent animation of this process, please click on this link:


STATION 2: WHAT IS A WATT?

A. A metric unit of power, used in electric measurements, to give the rate at which energy is used.

B. Explain that 1,000 watts = 1 kilowatt

C. Show pictures of the electric devices you will be testing and have students guess how many watts they use.

We burn fossil fuels to create energy. From keeping warm in our house, to fuelling our cars, to growing our food, to manufacturing our MP3 players, energy is used. It is either burned directly -- gas is burned in your boiler, for example, and gasoline is burned in your car, or it is burned in a power station to drive turbines which generate electricity. Fossil fuels are also burned at various stages in the process of creating food, products and services for our consumption. The total carbon which we as individuals are responsible for is called our carbon footprint.
STATION 3: BACKGROUND ON ENERGY AND SAVING ENERGY

A. What is Energy?

Energy comes in different forms:

<table>
<thead>
<tr>
<th>Heat (thermal)</th>
<th>Light (radiant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motion (kinetic)</td>
<td>Electrical</td>
</tr>
<tr>
<td>Chemical</td>
<td>Nuclear energy</td>
</tr>
<tr>
<td>Gravitational</td>
<td></td>
</tr>
</tbody>
</table>

Energy is in everything. We use energy for everything we do, from making a jump shot to baking cookies to sending astronauts into space.

There are two types of energy: “Stored” (potential) energy and “Working” (kinetic) energy. For example, the food you eat contains chemical energy, and your body stores this energy until you use it when you work or play.

B. What are Sources of Energy?

The chart below shows the 2012 average breakdown of U.S. Energy Consumption, by source. You will note that the bulk of the energy consumed in the U.S. comes from non-renewable sources -- coal, petroleum (oil), and natural gas.

U.S. energy consumption by energy source, 2012

Total = 95 quadrillion Btu

Petroleum 36%
Natural Gas 27%
Coal 18%
Nuclear Electric Power 8%
Renewable Energy 9%

Total = 9 quadrillion Btu

Solar 2%
Geothermal 3%
Wind 15%
Biomass 49%
Biomass waste 5%
Biofuels 22%
Wood 22%
Hydropower 30%

Note: Sum of components may not equal 100% due to independent rounding.
Electric generation fuel mixes vary from state to state and region to region, depending upon the availability and cost of fuels located there.

You can use the national average, but to really give a perspective on the differences in electricity generation state-by-state, it’s a good idea to enter your state-specific data into the carbon calculator.

- Click on this link: [http://www.eia.gov/state/](http://www.eia.gov/state/)
- Click on your state. Scroll down under blue “Quick Facts” box. Choose the 4th tab, “Electricity”. Make a note of the types of fuels used to generate electricity in your state and the gigawatt-hours (GWh) by fuel. Take it further and find the percentage each fuel accounts for.
- Compare your state’s fuel mix against several other states in the US. What differences do you see? Why do you think there is so much difference state-to-state?

**EXAMPLE:**

<table>
<thead>
<tr>
<th>California’s Net Electricity Generation</th>
<th>Pennsylvania’s Net Electricity Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal 66 GWh</td>
<td>Coal 7137 GWh</td>
</tr>
<tr>
<td>Nuclear 1645 GWh</td>
<td>Nuclear 5800 GWh</td>
</tr>
<tr>
<td>Natural Gas 8115 GWh</td>
<td>Natural Gas 3049 GWh</td>
</tr>
<tr>
<td>Hydroelectric 1417 GWh</td>
<td>Hydroelectric 421 GWh</td>
</tr>
<tr>
<td>Non-hydro, Other Renewables 3840 GWh</td>
<td>Non-hydro, Other Renewables 614 GWh</td>
</tr>
</tbody>
</table>

*“Non-Hydro Renewables and Other” includes generation from solar, wind, geothermal, biomass -- agricultural waste, municipal solid waste, landfill gas recovery, wood, pitch -- Hydrogen, batteries, chemicals, non-wood waste, purchased steam, sulfur, and miscellaneous technologies.*

STATION 4: HOW TO SAVE ENERGY

A. What is the difference between energy efficiency and energy conservation?
   • **Energy efficiency** refers to the amount of work you get out of a device compared to the amount of energy put into the device - the less energy a device uses to get X amount of work, the more efficient it is.
   • **Energy conservation** is essentially, not using energy: turning off your computer and monitor when not working with it saves energy, for example. Of course, building devices that do the same work with less energy, i.e. more efficiently, saves energy. So, in that way, the two concepts are related.

B. Ways to conserve energy:
   • When your cell phone is done charging unplug the charger from the wall
   • Change to Compact Florescent Light bulbs (CFLs)
   • Use products with Energy Star labels
   • Turn off lights, fans, and electronics when you’re not in the room
   • Don’t leave water running when you’re not using it

C. What other ideas do you have to conserve energy?

STATION 5: KILL A WATT DEVICE

A. What is this device used for?
   • It is used to act as a meter going between the item that draws the power and the power source.

B. How to use the Kill A Watt
   • Plug the meter in to the wall socket
   • Insert the plug for the electric device you want to test and turn the electric device on.
   • Choose the button for the data you want to collect, CO2, cost, or kWh.
   • Repeat this process

STATION 6: CALCULATING ENERGY USAGE AND COSTS

A. Converting Watts to Kilowatts and cost per year

<table>
<thead>
<tr>
<th>Electricity is measured in kilowatt-hours (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kilowatt = 1000 watts</td>
</tr>
<tr>
<td>kWh = kilowatts x hours the appliance is on</td>
</tr>
<tr>
<td>To get kilowatt-hours, take the wattage of the device, multiply by the number of hours you use it, and divide by 1000.</td>
</tr>
<tr>
<td>(Dividing by 1000 changes it from watt-hours to kilowatt-hours.)</td>
</tr>
</tbody>
</table>

B. Electricity Cost

- The cost of electricity depends on where you live, how much you use, and possibly when you use it.
- Convert each devices watt reading to kilowatts and cost per year and record the results in your table.

The electric company measures how much electricity you use in **kilowatt-hours (kWh)**. Your bill might have multiple charges per kWh and you have to add them all up to get the total cost per kWh.

**Electricity rates vary widely.** Prices are usually highest for residential and commercial consumers because it costs more to distribute electricity to them. Industrial consumers also use more and can take their electricity at higher voltages so it does not need to be stepped down. These factors make the price of power to industrial customers closer to the wholesale price of electricity. The cost to generate electricity actually changes minute-by-minute. However, most consumers pay rates based on the seasonal cost of electricity. Changes in prices generally reflect variations in electricity demand, availability of different generation sources, fuel costs, and plant availability. Prices are usually highest in the summer because more expensive generation is added to meet the higher demand.

The average retail price of electricity in the United States in May 2014 was 10.21 cents per kilowatt-hour (kWh). The average prices by type of utility customer were:

- Residential: 12.8¢ per kWh
- Commercial: 10.5¢ per kWh
- Transportation: 9.9¢ per kWh
- Industrial: 6.8¢ per kWh

Schools would fall under the “commercial” pricing.

C. Graphing

- After you have converted to cost per year make a bar graph of the data, with device on the x axis and cost on the y axis. For each device make sure you plot the cost per year with the device turned on and the cost per year with the device turned off.
- Ask what conclusions can be made from the bar plot.
ACTIVITY WORKSHEET

Name: _______________________________________________ Date: _______________________

1. Do you think that electrical devices -- computers, Xbox, Wii, printers, cell phone chargers, etc. use electricity and cost money when they are turned off? Why?

2. Use the energy meter device to take the watt reading when the device in turned on and when the device is turned off and record it in the Measuring Electricity Table. Use a calculator to determine the cost per year when the device is turned on and when the device is turned off.

<table>
<thead>
<tr>
<th>Device</th>
<th>Watts Turned On</th>
<th>Watts Turned Off</th>
<th>Hours Used Per Day</th>
<th>kWh Used Per Year (number)</th>
<th>Cost per Year Turned On = kWh Annual Cost</th>
<th>Cost per Year Turned Off = kWh Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projector or SMART Board</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pencil Sharpener</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laptop or Tablet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal Microwave, Refrigerator, Phone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Cameras</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Use the data from your table to make a double bar graph. See Figure 1 for an example of how to make a double bar graph.

![Double Bar Graph Example](image)

4. What conclusions can you make from your double bar graph? Is it important to unplug devices when you are not using them?
Involving the Community

Involving a diversity of people in your Eco-School program will provide access to valuable sources of advice, financial support and all kinds of practical help.

Your local community (parents, local businesses, resource specialists, local authorities, etc.) offers an even wider range of benefits for your Eco-Schools program. By expanding your classroom to include these individuals, you will strengthen your program and enhance its effectiveness. At the same time, you will raise the profile of your school in your community and help educate others beyond the school walls.

Many Eco-Schools programs around the world incorporate a school-wide Day or Week of Action. The event provides an opportunity for everyone in the school and the local community to come together to help achieve some of the targets set out in your Eco-Action Plan. Even more important is the day-to-day involvement that the whole school and local community can provide.

The following are some ideas for incorporating the whole school and the local community into your program. Use your students to add even more ideas.

**Involving the local community:**
- Produce a newsletter to keep parents updated about the Eco-Schools process, and send copies to other members of the community, such as local councils, churches, and businesses
- Send letters to local businesses seeking support for initiatives
- Invite resource specialists from the community to give talks at the school or offer help with particular tasks
- Submit press releases publicizing Eco-Schools activities, research results and achievements
- Submit student research to online science fairs as well as local fairs
- Conduct community-wide surveys to gather information about environmental issues that are most relevant to residents
- Disseminate the school's Eco-Code within the community
- Invite people from the community to attend celebration events and/or assist with large scale projects
- Have students contact your local newspaper and ask the paper to publicize details about the success of your Eco-Schools USA Program.
Footnote – Lesson 1 A Green Revolution

