Forecast Earth's *A Planet In Change* Teacher Guide

Teacher Overview

Welcome to *Forecast Earth*! This Guide describes activities and lesson plans for middle school and high school science teachers to use in conjunction with the *Forecast Earth* episode entitled *A Planet In Change*.

All of the lessons tie into science classroom objectives and goals (indicated through reference to National Science standards.) Unless otherwise specified, each of the lessons is appropriate for students in grades 5-12.

Although all of the lessons will be stand-alone, the length of time required to complete them will vary. In some instances, only one class period will be required; others will need additional time to monitor experiments, modify hypotheses, and prepare reports. Finally, the lessons have been arranged from foundational to successively more complex so that they may be used in sequence from Lesson 1 to Lesson 5. Unless otherwise indicated, the lesson will use a viewing of the episode as a springboard for the classroom activity.

To help you better integrate a lesson into your existing curriculum plan, each lesson includes an overview of its focus, background information, teacher steps specific to the activity, additional resources, and reproducible handouts for students. Further, some lessons identify a more narrow audience (either 5 – 8 or 9 – 12) for which they are appropriate. The lessons also include brief ideas for extending or modifying them to better accommodate your (and your students') needs.

Included in this Guide is a "Frequently Asked Questions" section that provides additional information to help you gain a better understanding of how to use this resource.

How to Use This Guide and the *Forecast Earth* Program

This Guide is designed for use in conjunction with the *Forecast Earth* programming episode entitled *A Planet In Change.* The program will air commercial-free in the Cable in the Classroom time slot (from 4:00 – 4:30 am EST) on The Weather Channel for you to tape and show in your classroom. The episode will be broadcast throughout the year as part of the Forecast Earth series, so be sure to check www.weatherclassroom.com frequently for the programming schedule. The series examines the planet's environmental health, often weaving in the impact of weather on the environment. After showing the video, you can use any or all of the lesson plans included in this Guide as an engaging way to help meet some of your classroom goals and objectives.

Teacher Background Information

Before using these lessons, you should be familiar with the Science as Inquiry method. The National Science Education Standards lists Science as Inquiry as an important content standard at all grade levels. Since students are naturally curious, they should be encouraged to make observations and ask questions about the world in which they live, and they should try, in an organized manner using the tools of science, to explain their observations. Weather events are often firsthand experiences for students, around which you can encourage real-world applications of science concepts and procedures. In other words, the lessons provided in this Guide are an excellent opportunity to for you and your students to add more inquiry-based approaches to classroom activities.

It is also important to be comfortable using technologies such as the Internet to help plan, organize, and deliver instruction to your students. Although the lessons in this Guide may be done without use of on-line resources, the activities are designed to enhance student learning about weather and areas of our lives impacted by our weather.

Lesson Descriptions

Lesson 1: It's Getting A Little Warm in Here, Isn't It?
Grade Levels: 5-12

In this lesson, students will have the opportunity to set up and implement their own market research study regarding public perceptions of global change. In a pre-planning session, they will brainstorm what they believe are the greatest misconceptions about global warming, the greenhouse effect, etc. This will provide an initial barometer reading regarding the erroneous thinking and contradictory perceptions on this subject. They will then research the topic on the Internet and via other resources to adjust or confirm the parameters of their study. Additional research will provide models on how to prepare a man-in-the-street market research questionnaire that will produce valid, measurable data. They will then prepare the questionnaire and begin their interviews in some or all of the suggested market segments.

Lesson 2: Kyoto Protocol Role Play/International Summit
Grade Levels: 5-12

According to *The New York Times*, Russia will soon join 120 other nations in signing the global environment protection treaty known as the Kyoto Protocol. The fact that the United States is not a signatory raises a number of questions about our country's motives and about the treaty itself. Why is this so? Are we taking a short-term or long-term view? Are we risking global disaster to accomplish our own immediate social, political, and economic goals? Will the Kyoto Protocol cost jobs here and abroad? Will it successfully decrease global warming? Do all countries concur regarding the implications of the treaty?

In this lesson, students will research these questions as well as the positions of our administration, and various countries and organizations. Students will also be given a synopsis of the IPCC (International Panel on Climate Change) report on Global Climate Change, the Kyoto Protocol, and other information on human impacts on the environment. After studying their materials, students will role-play key representatives from the United States, developing nations, and leading signatories of the treaty in a mock international summit on the Kyoto Protocol. This activity will help students understand the interface between science and international political decision-making.

Lesson 3: Greenhouse Effect Experiment
Grade Levels: 5-12
The Forecast Earth episode *A Planet in Change* spotlights the impact of human generated emissions of greenhouse gases. In this lesson, students will be asked to design and build a working miniature greenhouse-warming environment by using materials of their own choice. This will require both research and creativity. After students have determined a course of action and constructed their model, they will collect, analyze, and synthesize data over a predetermined period of time. This data will then be translated into a report and presented to the rest of the scientific community (classmates or other student groups) who will be asked to scrutinize the presentation and suggest alternative explanations. The lesson can also be used to challenge students to create and experiment with their own scenarios related to greenhouse gas pollution. As an extension to this activity, students can brainstorm and experiment with new methods of reducing greenhouse gases and reversing the global warming trend.

Lesson 4: Greenhouse Gas Mileage
Grade Levels: 5 – 12
In this lesson, students will study their personal contribution to one of the most harmful effects of transportation emissions – global warming. They will create tables to compare the fuel economy and subsequent carbon dioxide emissions from various nameplates over a year's time. By calculating the relationship between gas mileage and carbon dioxide emissions in their own automobiles, students will see how energy efficiency can reduce global warming.

Lesson 5: Personal Energy Consumption Audit
Grade Levels: 9-12
In this assignment, students will examine their own family's personal energy consumption habits and the impacts of those habits on the environment. They will start by determining how much power various appliances around their homes consume. Then they will calculate the approximate monthly cost of operating each appliance based on the cost of electricity. Having a thorough understanding of the dynamics of their own practices will provide a natural transition to understanding the energy dynamics at community, national, and global levels. Students will also see how positive changes at an individual level can be amplified to the same degree to help reverse the trend of deterioration.

Important Terms

- Global warming
- Greenhouse effect
- Fuel economy
- Fixation

Frequently Asked Questions

Q: How can I best use the Forecast Earth program and teacher guide to help my students learn about weather?

A: It is best to preview the program before sharing it with your students. As you watch the video, make a list of questions that you may want to ask your students about it. You may also jot down key concepts you want to discuss in class. Browse the Teacher Guide to get a general idea of the lessons available. Show the program to your students and assign them a task to accomplish as they watch the video. It may be a simple task such as listen for certain key words or a more challenging task such as taking notes. Pausing the program in key spots is another Best Practice to consider. After the viewing, discuss the information from the video, emphasizing those terms that students will investigate in the lesson plans.

Q: Which lessons or activities are best for my students?

A: It depends on the grade level and type of students you teach. The lessons and activities are designed for a range of student ages and abilities. The lessons are mostly geared for grades 5-12, but there are also suggested modifications and extensions for each lesson. Of course, state-mandated curriculum standards might also affect your choices.

Q: The lessons reference the National Education Science Standards. Are these standards applicable to my students?

A: Yes. The National Education Science Standards are appropriate benchmarks for all students. Many states use the National Standards to develop curriculum guidelines for their students.

Q: I know my content area well, including direct ties to weather, yet I don't feel like I understand the elements of weather outside of that. How can I learn more before teaching these lessons to my students?

A: You are not expected to be an expert in weather before teaching these lessons. The background information in each lesson plan includes information that is relevant to the lesson. Web pages are also cited as references if you need additional information about a weather topic or phenomena before using a lesson.

Lesson 1: It's Getting A Little Warm Here, Isn't It?

Audience:
Grades 5-12

Lesson Overview
In this lesson, students will have the opportunity to set up and implement their own market research study regarding public perceptions of global change. In a pre-planning session, they will brainstorm what they believe are the greatest misconceptions about global warming, the greenhouse effect, etc. This will provide an initial barometer reading regarding the erroneous thinking and contradictory perceptions on this subject. They will then research the topic on the Internet and via other resources to adjust or confirm the parameters of their study. Additional research will provide models on how to prepare a man-in-the-street market research questionnaire that will produce valid, measurable data. They will then prepare the questionnaire and begin their interviews in some or all of the suggested market segments.

Objectives:

- Create an understanding of the public's awareness and misconceptions of global warming
- Learn how to design and implement a market research survey and research report.
- Develop persuasive presentation skills.

National Standards Addressed:
This lesson addresses the following National Science Education Standards:

Content Standard A
As a result of activities in grades 5-8, all students should develop
- Abilities necessary to do scientific inquiry.
- Understandings about scientific inquiry.

Content Standard F
Grades K-12
Understand how human actions modify the physical environment.
- Understand how physical systems affect human systems.
- Understand the changes that occur in the meaning, use, distribution, and importance of resources.

Grades 5-8

Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.

Desired Outcomes:

After completing this lesson, students will:

- Understand the complexities and consequences related to global warming
- Know how to correct the many false perceptions of this topic
- Develop market study techniques that can be used elsewhere

Teacher Prep Time:

15-30 minutes

Class Time:

Video: 25 minutes
Research: 180 minutes
Implementing the survey: 60-360 minutes

Materials Needed:

- *Forecast Earth: A Planet in Change* video

Background:

This lesson will lay the foundation for subsequent lessons on global warming. It will not only require you to have a general knowledge of global warming but also an understanding of market research techniques and studies, and how they are conducted. You may want to invite a marketing teacher to visit your class and explain the essential elements of a good market study. (See Step 2 under Research for specific details.) This cross-department integration will also show students how their current subjects of study are interconnected, not stand-alone. On a more practical note, you will also be garnering a valuable ally who will support out-of-classroom activities required for this study. In order for students to conduct research on global warming, you may also need to schedule one class period in the library and/or computer classroom where students will have access to the Internet.

The activity is appropriate for students of all academic levels.

Lesson Steps

Introduction

1. Explain to students that they will be conducting a class market research study about global warming and the public's misconceptions and lack of understanding on the subject.
2. Ask some general questions regarding the following topics: global warming; hole in the ozone; greenhouse gases; Kyoto Protocol (Treaty); U.S. position on global emissions standards, etc. Write answers/comments on the board as they respond.
3. Watch the episode: *Forecast Earth: A Planet in Change.*
4. Spend a few minutes going over the previous answers on the board and noting any changes of opinion and/or definitions.

Research and Survey Development

1. Arrange for class time for students to conduct research on the topic of global warming. Because of the complexity of the topic and the many differing opinions, you may need to hold additional classroom discussions to go over questions that students may have.
2. Next, explain the essential elements of a market research study and report (or have a guest marketing teacher come in to do so.) The explanation should include such general topics as: market sampling categories (age, gender, occupations etc); samples of open-ended/closed-ended questions and the merits of each; format (verbal, written, T/F, multiple choice, etc), proper wording of questions; types and merits of different types of data charts (pie, bar, mountain, graphs etc); narrative report of the study. You may also include PSA formats as well as a critical time path calendar.
3. Have students brainstorm ideas about the survey format, and the questions that will be included in the survey. The preliminary classroom discussion will help steer them in the right direction.
4. Work with students to develop a critical time path for the study. This should include deadlines for data collection, analysis, written report and chart preparation, presentation, media announcements etc. You may wish to identify which components must be competed in class and which will be homework assignments.
5. When the survey finalized, print it out and assign areas of coverage to students. Suggested groups to include in the study are:
    - Students in the hallway, cafeteria, athletic events etc.
    - Faculty and staff
    - Parents and neighbors
    - Local politicians and civil servants
    - Pedestrians on the streets and/or customers in shopping malls (with permission of management)

Findings and Reports

1. When the surveys are complete, each student should prepare a report of his/her findings. The report may include:
    - Paragraph descriptions of the results of the study, along with correct facts and statistics on each category.
    - Pie charts or bar charts that depict those results.
    - Charts that compare the misconceptions of each of the market segments (students, faculty, parents etc)

2. Reports can then be presented in the class and via any or all of the following:
   - Posters in the classrooms and/or cafeteria
   - School newspapers, radio and/or television stations
   - School web site
   - School assembly
   - PSA materials sent to local media outlets

Academic Extensions/Modifications

As an extension to this activity, students could opt to write a position paper explaining why they think, if in fact their findings show it, a general misunderstanding of global warming exists. Students should be sure to offer ideas on why the lack of understanding exists (if it does) across the groups surveyed, and suggest a proposed solution that might help address the problem for one or more of the groups surveyed.

Lesson 2: Kyoto Protocol Role Play/International Summit

Audience:
Grades 5-12

Lesson Overview
According to *The New York Times*, Russia will soon join 120 other nations in signing the global environment protection treaty known as the Kyoto Protocol. The fact that the United States is not a signatory raises a number of questions about our country's motives and about the treaty itself. Why is this so? Are we taking a short-term or long-term view? Are we risking global disaster to accomplish our own immediate social, political, and economic goals? Will the Kyoto Protocol cost jobs here and abroad? Will it successfully decrease global warming? Do all countries concur regarding the implications of the treaty?

In this lesson, students will research these questions as well as the positions of our administration, and various countries and organizations. Students will also be given a synopsis of the IPCC (International Panel on Climate Change) report on Global Climate Change, the Kyoto Protocol, and other information on human impacts on the environment. After studying their materials, students will role-play key representatives from the United States, developing nations, and leading signatories of the treaty in a mock international summit on the Kyoto Protocol. This activity will help students understand the interface between science and international political decision-making.

Objectives:

- Build an understanding of human impact on climate.
- Develop persuasive presentation skills.
- Become more familiar with the political decision-making processes.

National Standards Addressed:
This lesson addresses the following National Science Education Standards:

Content Standard A
As a result of activities in grades 5-8, all students should develop
- Abilities necessary to do scientific inquiry.
- Understandings about scientific inquiry.

Content Standard F
Grades K-12

- Understand how human actions modify the physical environment.
- Understand how physical systems affect human systems.
- Understand the changes that occur in the meaning, use, distribution, and importance of resources.

Grades 5-8

- Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.

Desired Outcomes:

After completing this lesson, students will:

- Develop opinions and positions concerning international environmental treaties and policy.
- See that science impacts International policy, which in turn impacts diplomatic relationships between governments.

Teacher Prep Time:

15-30 minutes

Class Time:

Video: 25 minutes
Research: 180 minutes
Mock International Summit: 60 minutes

Materials Needed:

- *Forecast Earth: A Planet in Change* video
- Reproducibles
- Pictures depicting indirect evidence of global warming
- Graphs and other data related to global warming

Reproducibles:

This lesson contains reproducibles that provide background information on the Kyoto Treaty and the greenhouse effect, as well as a summary of the IPCC report, Sample Data handouts, and student role cards.

Background:

To prepare for this lesson, you will need to do some preliminary homework that will help you facilitate a discussion on the controversy behind global climate change. For starters, you should know what is implied by the terms "global warming" and "the greenhouse effect." If possible, **c**ollect some satellite photos that show indirect evidence of global warming such as receding glaciers, desertification, or flooding. Prepare photos or other visual aids that depict a variety of anthropogenic (human generated) versus natural sources of greenhouse gases. You may also want to collect graphs of sea level increase, temperature increase, carbon dioxide increase etc. The United States Environmental Protection Agency Global Warming Sites at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html provides information that will help students delve into sources, impacts, solutions, and actions related to global warming and may have some pictures and charts of your own region – a great way to bring the discussion home.

In class, you will use these materials while leading a discussion on whether global warming is a real danger to our planet or simply an overblown myth. When the class has a satisfactory grasp of the topic, students will be given role cards which will help them research from the perspective of the person on their card. They will then present their sides of the issue in a class forum that will demonstrate the complexity of this subject, as well as the wide diversity of interpretations and interests.

You may also wish to provide time in class for students to conduct research over the Internet or in the library. The activity is appropriate for students of all academic levels.

Lesson Steps

Introduction

1. After showing the program *"A Planet in Change,"* lead a brief discussion concerning world opinion on global warming and the history of the Kyoto Protocol. You can start by saying that while most scientists are convinced that the Earth is warming up at a catastrophic pace, others believe that more data is needed. And still others say that the current warming trend is just one stage of a normal cycle that will soon phase out.
2. Distribute the Sample Data reproducibles. Using the data charts and photos you collected, solicit answers and discussion on the following questions:
   - Is the Earth just in a natural cycle of warming? Why do you believe that?
   - How accurate are the computer models that show that the Earth is warming? What are the consequences if they are right? If they are wrong?
   - Which creates the most carbon dioxide pollution: volcano eruptions or the burning of fossil fuels by humans?
   - What are some other sources of carbon dioxide pollution and ozone depletion? (Decomposition of organic material in landfills; deforestation; rice paddies; livestock; swamps; etc.)

Research and Role Play

1. Describe the role-play activity and set the time limits and dates for the Summit.
2. Divide the class into eight Planning Teams, each with three to five students. Distribute copies of the reproducibles on the Kyoto Protocol, IPCC summary, and role cards to each group.
3. Assign one role card to each group. The cards represent the world community stakeholders listed in the reproducible sheet at the end of the lesson. Explain that each student in the group is an advocate for the person or group on their card. Provide time for group research on the positions in class or assign it as homework (see Academic Extensions/Modifications section.)
   Note: You may also wish to allow your students to select a person, organization or perspective not listed on the role card.
4. Ask each team to write a global warming policy statement against or in support of the Kyoto Protocol to be presented at a mock International Environmental Summit on Global Climate Change. Ask them to assign a spokesperson to present their policy statement.
5. Hold the Summit (you may wish to act as moderator of the summit or assign that responsibility to a student.) When each presentation is finished, ask the group to defend its position by fielding questions from the class. When a group finishes its presentation and Q&A, the next group will take the floor. This will continue until all groups have weighed in.
6. When all presentations are finished, ask groups if they'd like to modify their written statements on the basis of new information gained from the class.
7. As closure, ask students for suggestions on creating an action plan (local, regional, and international) that could result in better environmental policy making decisions.

Academic Extensions/Modifications

Given the limiting time restraints of a class period, you may want to limit the research step by passing out the role cards as described above and having students formulate their opinions with just the information provided on the cards. However, if you extend the time limits, students can do their own research to discover the positions of the assigned interest groups on their own. Either way, students should represent often-conflicting viewpoints, and thus be forced to discuss and resolve the many considerations necessary for signing international environmental treaties.

Additional Resources:

- Environmental Protection Agency Climate Change Site: http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html
- Mauna Loa Climate data: http://www.smate.wwu.edu/teched/co-2.html

Reproducible:

THE KYOTO PROTOCOL

On this page you will find summaries of a few key terms and issues related to the Kyoto Protocol. For more detail, please visit the following website:

http://www.bbc.co.uk/science/hottopics/climatechange/kyototreaty.shtml

The Kyoto Treaty

Under the auspices of the United Nations, the 1997 Kyoto Treaty initially required all participating nations to reduce greenhouse gas emissions by 5.2% by 2007. Although any decrease is a step in the right direction, this goal addresses only one aspect of the problem – the continued damage to the atmosphere. It does not take into account that gases already in the atmosphere will remain there for at least a hundred years. That's why the Intergovernmental Panel on Climate Change believes that any meaningful atmospheric healing will require 60% reduction in harmful emissions… starting now. That's both a logistical nightmare and an economic burden that most nations cannot – or will not -- contemplate. One of the treaty's other sticking points is that more pressure is put on some countries to correct their industrial processes while others earn tradable carbon emission *credits* that seem to reward them for maintaining – or even increasing - high levels of emissions. At the same time it hardly seems fair to place a huge logistical and economic burden on small countries that because of their state of economic and industrial development have contributed little to the problem.

By 2001, even the 5.2% reduction (and some other provisions) seemed too troubling for the United States so they withdrew from the treaty. Subsequent watered-down versions were also rejected by the United States administration. Another holdout, Russia, after hosting a conference on climate change in 2003, eventually resolved its own points of contention and joined the treaty in 2004.

Greenhouse Gases

Greenhouse gases are generated by nature and by industry. The term encompasses water vapor, carbon dioxide, methane, nitrous oxide and CFCs (chlorofluorocarbons). CFCs are the only greenhouse gases that result entirely from industrial processes. As their name implies, CFCs contain chlorine, fluorine and carbon compounds – essential ingredients of aerosols, air conditioners, and coolants. There is a good-side/bad side aspect to the CFC problem: there are less CFC's in the atmosphere, but the ones that are there pose a more serious danger to the greenhouse effect than other gases. Recent changes in industrial standards (like the banning of certain CFC compounds and the auto industry's switch to less harmful A/C compounds) have helped reduce the proliferation of CFCs, but they still remain a very real threat.

Greenhouse Effect

Under normal conditions, rays from the sun pass through greenhouse gases in our atmosphere, reflect off the Earth or are transformed into heat, and head back into the atmosphere with a little less radiation and a different wavelength. But instead of passing through the atmosphere on the return trip, the altered radiation is absorbed by particles of greenhouse gas that then become warm. The accumulation of these particles forms a layer around the Earth and if left unchecked, will warm the Earth itself. This process is called the ***greenhouse effect*** because it follows the same principles that make greenhouse horticulture so efficient.

It should be noted that fossil fuels are not the most efficient energy trappers out there, but their carbon emissions form the biggest threat because their usage is so widespread. It should also be noted that not all scientists agree with this theory or the severity of danger it portends.

Reproducible:

Summary of the International Panel on Climate Change (IPCC) Report

The following is a summary of a report from the Intergovernmental Panel on Climate Change (IPCC).
Abridged from: http://www.grida.no/climate/ipcc_tar/wg1/005.htm

Global Warming Confirmed By New Technology, More Data, Broader Coverage

Data collected since the Second Assessment Report (SAR[4]) shows that:

1. In the last 100 years, the global average surface temperature has risen by 0.6°C.
   - Urban heat island effects and other known variables were taken into account.
   - Two of the most dramatic warming periods were 1910 – 1945 and 1976 – 2000.
   - Globally speaking, the 1990s was probably the warmest decade; 1998 the warmest year since 1861.
   - New analyses of proxy data for the Northern Hemisphere indicate the following:
     - Temperature rise in the 20th century is probably the highest of any century during the past 1,000 years.
     - In the Northern Hemisphere, the 1990s was the warmest decade and 1998 the warmest year.
     - Little is known about prevailing conditions in the Southern Hemisphere prior to 1861.
   - From 1950 to 1993, average night-time daily minimum air temperatures over land increased by about 0.2°C per decade – about twice that of daytime temperatures over the same period
     - The freeze-free season in many mid- and high latitude regions has increased.
     - Sea surface temperature over this period is about half that of the mean land surface air temperature.
2. Temperatures have risen during the past forty years in the lowest 8 kilometers of the atmosphere
   - Global atmospheric temperatures and surface temperature have both risen about 0.1°C per decade.
   - Since 1979, satellite and weather balloon measurements show that the lower atmosphere has changed by +0.05 ± 0.10°C per decade, and the average surface temperature has increased significantly by +0.15 ± 0.05°C per decade. This difference occurs primarily over the tropical and sub-tropical regions.
   - The atmosphere and the surface are influenced differently by factors such as stratospheric ozone depletion, atmospheric aerosols, and the El Niño phenomenon.
   - Precautionary note: There may be short time periods (e.g., 20 years) that undergo different temperature trends.

Reproducible:

Summary of the International Panel on Climate Change (IPCC) Report

3. Snow cover and ice have decreased globally
    - Satellite data shows that in the last forty years, snow cover has decreased about 10%.
    - Over the last hundred years, the mid- and high latitudes of the Northern Hemisphere have lost about two weeks time of annual duration of lake and river ice cover.
    - Non-polar mountain glaciers have decreased in the last hundred years.
    - Since the 1950s Northern Hemisphere spring and summer sea-ice coverage has decreased by about 10 to 15%.
    - There has been about a 40% decline in Arctic sea-ice thickness during late summer to early autumn, but a considerably slower decline in winter sea-ice thickness.

4. Global average sea level has risen; ocean heat content has increased.
    - Global average sea level rose between 0.1 and 0.2 meters during the 20th century.
    - Global ocean heat content has increased since the late 1950s, which is the period for which adequate observations of sub-surface ocean temperatures have been available.

Reproducible:

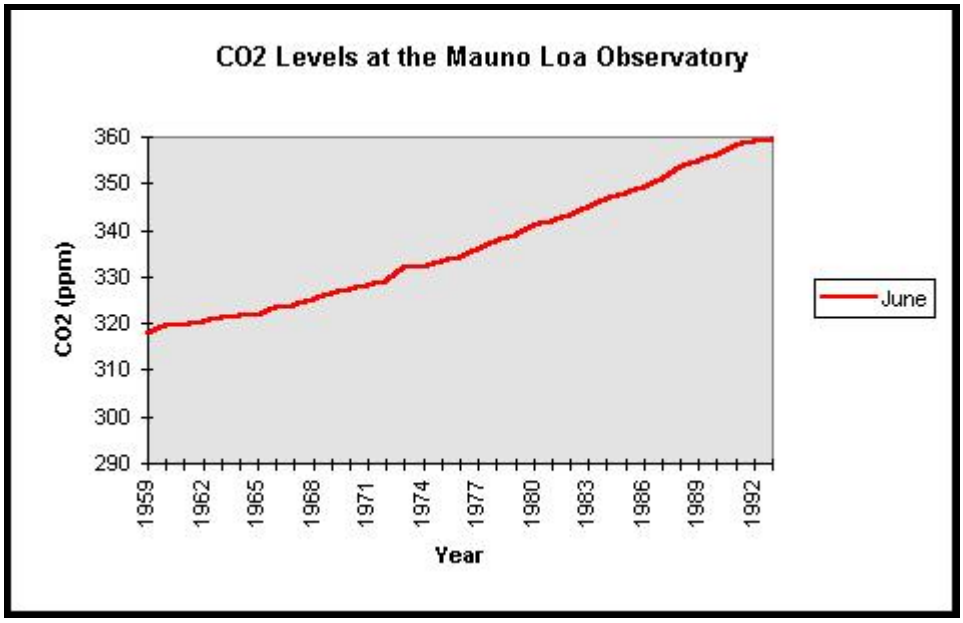
International Environmental Summit on Global Climate Change
Role Cards

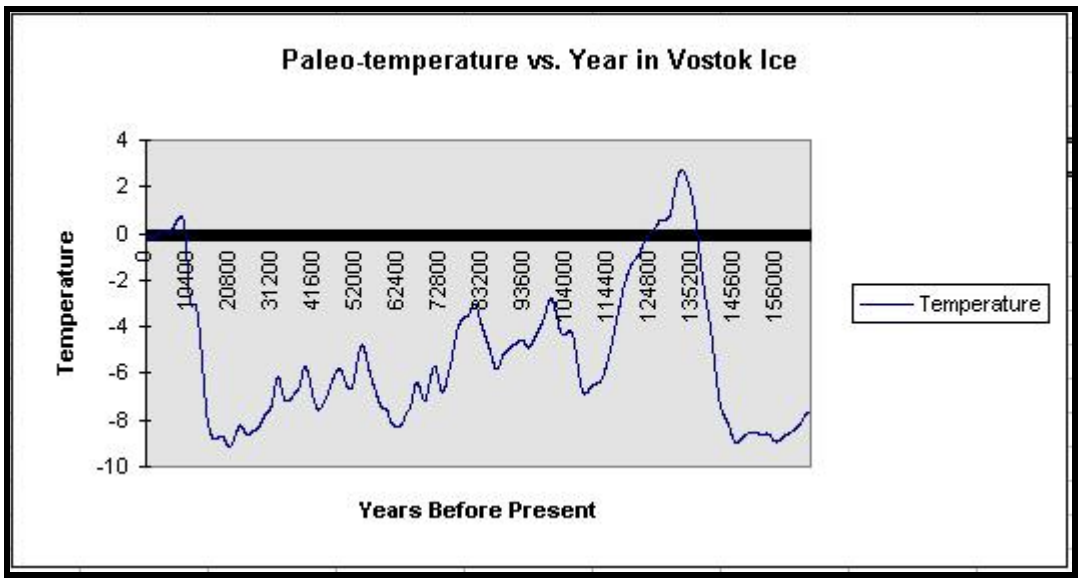
Using the information on your role card, develop a position statement that includes points that will be most beneficial to your country or organization.

Ai-Ben Haad An Economist from an industrialized mid-east country and an expert at cost benefit analysis.	**Eric Nohulpinzeit** German Foreign Minister, a Green party member, is in support of reduction in carbon emissions.	**Petr Feldownov** Deputy Prime Minister of Russia. A pro-Kremlin politician in agreement with the President of Russia.	**Ming Tomein** Represents Chinese Premier Zhu Rongji, who announced on September 3, 2002 at the World Summit on Sustainable Development that China has approved the Kyoto Protocol to the United Nations Framework Convention on Climate Change.
Pohl Zapahrt A European Union Industrialist ready to launch the world's first international carbon-trading system, which allows industrialized countries to buy or sell parts of their national emissions quota allocated by the Kyoto Protocol.	**Ivan T'ghettin** A climate scientist from Kazakhstan who believes climate models show a compelling case that global warming is real and wants developing countries to be given credit for developing 'Clean Development Mechanisms' (CDM).	**Bob N. Ferappuls** Power Company lobbyist for a local electrical power company in Alberta Canada that depends primarily on coal. Concerned about the economic consequences of reducing greenhouse gases.	**Lotta Pesos** Vice Chancellor of Costa Rica. Concerned for the defense and protection of the environment for the benefit of humanity. Demands to be paid by industrialized countries for preserving rainforests because they are long term storage sinks for greenhouse gases.

Reproducible:

Sample Data

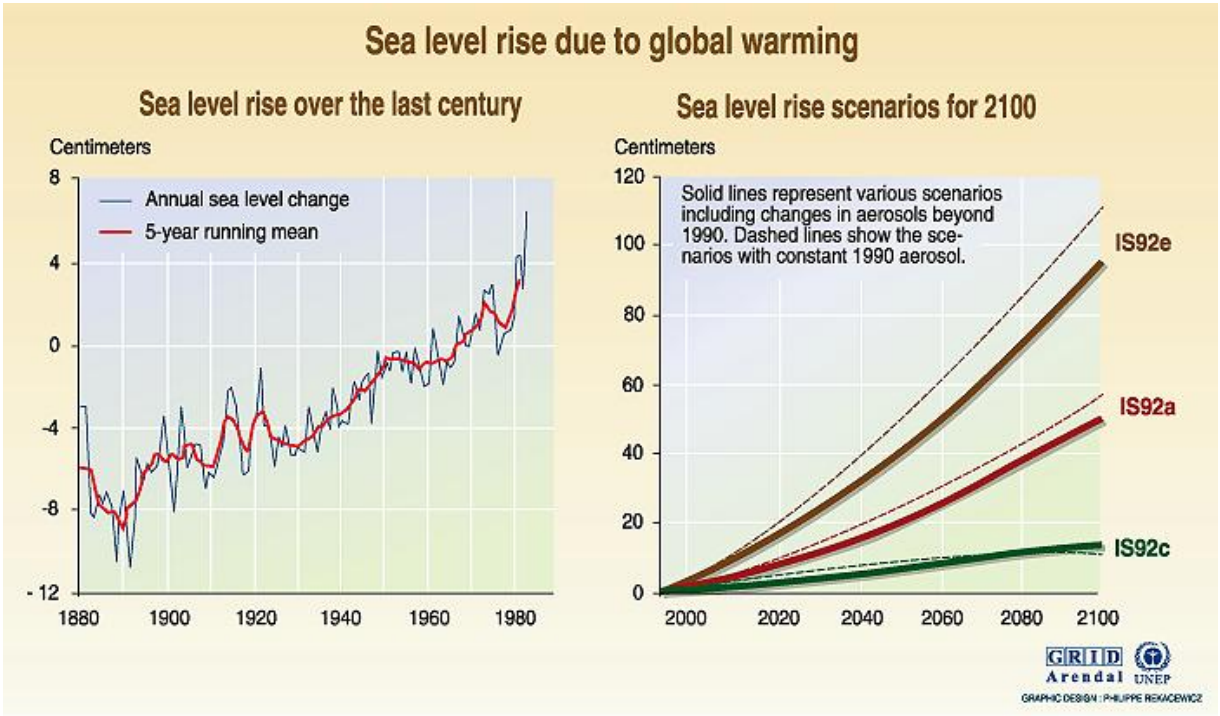




Source: http://www.smate.wwu.edu/teched/co-2.html

Reproducible:

Sample Data, continued



Source: Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996; Sea level rise over the last century, adapted from Gornitz and Lebedeff, 1987.

Source: http://www.ipcc.ch/pub/spm22-01.pdf

Lesson 3: Greenhouse Effect Experiment

Audience:
Grades 5-12

Lesson Overview
The Forecast Earth episode *A Planet in Change* spotlights the impact of human generated emissions of greenhouse gases. In this lesson, students will be asked to design and build a working miniature greenhouse-warming environment by using materials of their own choice. This will require both research and creativity. After students have determined a course of action and constructed their model, they will collect, analyze, and synthesize data over a predetermined period of time. This data will then be translated into a report and presented to the rest of the scientific community (classmates or other student groups) who will be asked to scrutinize the presentation and suggest alternative explanations. The lesson can also be used to challenge students to create and experiment with their own scenarios related to greenhouse gas pollution. As an extension to this activity, students can brainstorm and experiment with new methods of reducing greenhouse gases and reversing the global warming trend.

Objectives:

- To demonstrate how human generated air pollutants affect our environment
- To build models as a way to simulate environmental phenomena in order to solve problems

National Standards Addressed:
CONTENT STANDARD A
As a result of activities in grades 5-12, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Life Science
CONTENT STANDARD F:

- Human activities can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.

RISKS AND BENEFITS

- Students should understand the risks associated with natural hazards (fires, floods, tornadoes, hurricanes, Earthquakes, and volcanic eruptions), with chemical hazards (pollutants in air, water, soil, and food), with biological hazards (pollen, viruses, bacterial, and parasites), social hazards (occupational safety and transportation), and with personal hazards (smoking, dieting, and drinking).

Desired Outcomes:

After completing this lesson, students will:

- Understand how to utilize physical models to investigate cause-and-effect scenarios.
- Recognize that individual activities impact personal air quality and global air quality.
- Construct models that can be used to demonstrate and compare how naturally occurring greenhouse gases (carbon dioxide and water) affect the temperature of a closed model.

Teacher Prep Time:

30 minutes

Class Time:

Video: 25 minutes
Activity 1 (model building): 60-180 minutes
Activity 2 (data collection) TBD by teacher
Activity 3 (presentation/discussion of findings): 60 minutes

Materials Needed:

- *Forecast Earth: A Planet in Change* video
- Reproducibles
- Materials needed for this activity are to be determined by students. The list below is what they are likely to request so have them on-hand for use:
  - soup cans
  - water
  - circulating fans
  - chunks of concrete
  - topsoil
  - stopwatches
  - ring stand
  - 60, 75, 100w bulbs
  - thermometers

- beakers
- white, silver and black spray paint
- ice cubes
- window sill
- plastic bags
- dry ice*
- thick gloves

Note: Students should not directly handle any dry ice. Thick protective gloves must be worn when handling dry ice.

Reproducibles

This lesson provides two rubrics that may be used to evaluate the experimental models and presentations given by the groups.

Background:

In a greenhouse, windows allow light from the sun to come in but do not allow heat to go back out. The gases in our atmosphere are like the transparent glass in a greenhouse, allowing light to go through, but then changing the light into heat and trapping it. This phenomenon – called the greenhouse effect – is being blamed for the increase in global temperatures over the last hundred years. And it is the *greenhouse gases* that are the problem. These gases include nitrogen oxides, chlorofluorocarbons (CFCs), carbon dioxide, methane and water vapor. Some of them are natural; some are anthropogenic (human generated). Although all of them absorb radiation well, some are more efficient than others – especially CFCs. The chief contributors to the greenhouse effect are the anthropogenic gases, most of which are the result of industrial emissions like carbon dioxide (CO_2). CO_2 is an excellent gas for students to work with because they can acquire it in its solid form (dry ice). Upon exposure to the atmosphere it will sublimate into the gaseous state.

Students may also wish to experiment with several other variables that can alter the sun's radiation and the greenhouse effect. Among these are:

- the surface it is striking
- the angle of incidence
- the medium(greenhouse gas) through which the light travels
- the reflectivity of the surface
- global circulation
- reflectivity of aerosols and other air-borne substances

These variables present an excellent opportunity to apply National Science Standards that ask teachers to engage students in science in order to develop their ability to think and act in ways associated with inquiry.

Lesson Steps:

Introduction and Models

1. To introduce the topic of greenhouse gases, show the *Forecast Earth A Planet in Change* video. Explain that in this activity, students will design and build a working miniature greenhouse-warming environment, using materials of their own choice.
2. Divide the class into groups and ask each group to brainstorm and research to identify causes of increased air pollution that result from human activities.
3. Groups must then:
   a) formulate a plan for a greenhouse gas experiment that can be conducted with simple models, and
   b) determine what materials and techniques could be used to conduct the experiment.
4. With the materials you have provided or students have collected, groups should construct a greenhouse model using common household materials.
   Note: You may wish to share the evaluation rubric with the groups for reference as they create their models.

Experimenting and Testing

1. When the models are completed, groups should commence their experiments, which will last for a predetermined amount of time.
2. Each group should test their model repeatedly to be sure that it will demonstrate conclusions clearly.
3. As the groups test, use the Analytical Rubric for Experimentation to evaluate the models.

Presenting Findings

1. Provide time in class for groups to analyze and synthesize their findings. Students should generate graphs, charts, and multimedia components, if possible, to use in a classroom presentation about their experiment.
   Note: You may wish to share the presentation evaluation rubric with the groups for reference.
2. Allow time for each group to present. Use the Science Presentation Evaluation Rubric provided. As each group presents, the rest of the class should scrutinize the presentation and suggest alternative explanations for the findings.

Academic Extensions/Modifications

Allow students to modify their models and conduct experiments to identify realistic steps we all can take to decrease greenhouse gases in our environment.

Additional Resources

For additional information on global warming, visit http://yosemite.epa.gov/oar/globalwarming.nsf/content/VisitorCenterEducators.html .

Reproducible

Analytical Rubric for Experimentation

Criteria	4 Points	3 Points	2 Points	1 point	Score
Has a plan for Investigation	The plan is complete	The plan is lacking a few details	The plan is missing major details	The plan is incomplete and limited	
Use of Materials	Manages all materials responsibly	Uses the materials responsibly most of the time	Some of the materials are mishandled	Does not use materials properly	
Collects the Data	Thorough collection of data	Some of the data is collected	Major portions of the data are missing	Data collection consists of only a few points	
				TOTAL SCORE	

Adapted from: http://www.gsu.edu/~mstnrhx/457/rubric.htm

Reproducible

Science Presentation Rubric

Group Name: _____
Date: _____
Class: _____

Presentation Evaluation	**4 points**	**3 points**	**2 points**	**1 point**
Participation	All team members participated equally in the presentation.	All but one member participated in the presentation.	All but two members participated in the presentation.	Only one member participated in the presentation.
Presentation Style	• Addressed all members of the audience • Used a multimedia approach (included a variety of visual, audio, or other presentation formats).	• Addressed most members of the audience. • Used a multimedia approach (included a variety of visual, audio, or other presentation formats).	• Addressed a <u>few</u> members of the audience. • Used speech and paper materials.	• Addressed only the graders of the presentation. • Oral presentation only. No other supporting materials used.
Delivery Strategies	Presentation demonstrates <u>excellent</u>: • organization • clarity of purpose • use of technical vocabulary • attribution of credible sources • use of accurate supporting evidence.	Presentation demonstrates <u>good</u>: • organization • clarity of purpose • use of technical vocabulary • attribution of credible sources • use of accurate supporting evidence.	Presentation demonstrates <u>some</u>: • organization • credible sources • supporting evidence.	Presentation demonstrates <u>lack</u> of organization and lack of supporting evidence.

Lesson 4: Greenhouse Gas Mileage

Audience:
Grades 5 – 12

Lesson Overview:
In this lesson, students will study their personal contribution to one of the most harmful effects of transportation emissions – global warming. They will create tables to compare the fuel economy and subsequent carbon dioxide emissions from various nameplates over a year's time. By calculating the relationship between gas mileage and carbon dioxide emissions in their own automobiles, students will see how energy efficiency can reduce global warming.

Objectives:
- Conceptualize how energy efficiency can reduce global warming by calculating the relationship between gas mileage and carbon dioxide emissions in automobiles.
- Form an opinion on why we do not use more fuel-efficient cars.
- Hypothesize about what policy changes would be necessary to make fuel-efficient cars more marketable.

National Standards Addressed:
This lesson addresses the following National Science Education Standards:

CONTENT STANDARD F
As a result of activities in grades 5-12, all students should develop understanding of
- Personal health
- Populations, resources, and environments
- Natural hazards
- Risks and benefits
- Science and technology in society
- Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.

RISKS AND BENEFITS
- Students should understand the risks associated with natural hazards (fires, floods, tornadoes, hurricanes, Earthquakes, and volcanic eruptions), with chemical hazards (pollutants in air, water, soil, and food), with biological hazards (pollen,

viruses, bacterial, and parasites), social hazards (occupational safety and transportation), and with personal hazards (smoking, dieting, and drinking).
- Individuals can use a systematic approach to thinking critically about risks and benefits. Examples include applying probability estimates to risks and comparing them to estimated personal and social benefits.

Desired Outcomes:

After completing this lesson, students will:
- Recognize the relationship between personal driving decisions, carbon emissions, and global warming.
- Appreciate the implications of selecting one automobile over another in terms of carbon dioxide generation.

Teacher Prep Time:

15 minutes

Class Time:

Video: 25 minutes
Activity: 90 minutes (time outside of class may be required for research)

Materials Needed:

- *Forecast Earth: A Planet in Change* video
- Various dealership pamphlets containing information concerning gas mileage
- Photos of various types of automobiles
- Calculator

Reproducibles

This lesson contains a reproducible that provides miscellaneous facts about emissions and global warming. It may be used as a handout or just as talking points for the instructor.

Background

Before beginning this lesson, review the latest information and possible solutions regarding automobile emissions and global warming. You may also want to gather statistics on the amount of carbon dioxide emitted each day by various countries and the number of automobiles estimated to be in them. If possible, gather dealership pamphlets containing information about gas mileage for sports utility vehicles, economy cars, gas-hogs, "green" machines, and some of the new prototype cars getting between 67 and 138

mpg. Prior to the lesson, post photos of these automobiles around the room. Ask students if they can estimate the amount of waste these automobiles produce. Ask them how they could find out how much carbon dioxide is produced from each type of car.

After the groups have presented, you may want to lead a discussion about the ways that human beings can reduce emissions (carpooling, high occupancy vehicle lanes, alternative fuels, hybrid cars, riding a bike or walking etc.)

Lesson Steps

1. After watching the program, *Forecast Earth: A Planet in Change,* lead a discussion concerning the greenhouse effect, global warming, the link between automobiles and global warming, and potential solutions to the problem. Distribute the Miscellaneous Facts handout for discussion, or simply go over the points included with the class.
2. Explain that, on average, for every gallon of gas consumed by a car, 20 pounds of carbon dioxide are emitted into the atmosphere. That 20 pounds includes not only the CO_2 from the car's exhaust, but also all the emissions from petroleum extraction, processing, transportation, car production, etc. Since the typical car on the road today gets 15 - 20 miles per gallon (mpg), a car accounts for more than 5 tons of carbon dioxide emissions per year!
3. Use photos and or dealership brochures of cars to lead a discussion about a) the amount of waste produced daily by different models of cars; b) the positive benefits and negative consequences of transportation.
4. Divide the class into small groups. Explain that each group is to research the fuel efficiency and other environmental impacts of specific classes of automobiles that are common today. The study should encompass a full spectrum of vehicles including sports utility vehicles, economy cars, gas-hogs, "green" machines, and some of the new prototype cars getting between 67 and 138 mpg. Data gathered should include information on safety, performance, fuel efficiency, pricing, and emissions standards. Using their own estimations of how many miles they drive each year, students should also calculate what the estimated CO_2 emissions in one year would be for the car type they have selected. (The group investigating hybrid vehicles will need to find out what the estimations are for carbon dioxide emissions per gallon for that car type.) Note: You may decide to assign a specific class(es) to each group or let them select their own. At minimum, each of the classes listed above should be included in the study. Time for research may need to be provided in class or assigned as homework.
5. Create a comparison table for the class to fill in, either on the board or as a handout. The table should include a column for fuel economy and CO_2 emissions in one year for each vehicle type.
6. When all groups are ready, have each one present their findings, filling in the information in the table for the class as appropriate.

7. When all groups have finished, pose the following questions to the class:
    a. Based on the data presented, which car would they purchase if given the option?
    b. What criterion do they use to purchase a car?
    c. How much carbon dioxide would each of the following cars emit in one year?
        1978 car that gets 15 mpg
        1995 Sports car that gets 25 mpg
        1984 Economy car that gets 35 mpg
        2004 Toyota Prius Hybrid car
        2004 Sports Utility Vehicle that gets 15 mpg
        2004 Hummer (largest consumer version)
    d. Which car is the least/most expensive to operate?
    e. Which would be the least/most to own? (Purchase price + fuel cost for 5 yrs)
    f. Which car is the least environmentally sound? Be sure to consider other variables besides carbon dioxide emission and gas mileage.
    g. Should the government get involved in creating policies to encourage alternative green cars? Why or why not?
    h. If we did produce cars with better fuel efficiency, what would be the impact on the oil and automotive industries?

Academic Extensions/Modifications

There are many variables that affect fuel consumption besides "city and hwy" driving. Students interested in the engineering aspects of fuel efficiency may investigate the influence of:

- Frontal area design (i.e. wind resistance or aerodynamic design)
- Spoilers and other wind impeders, such as west coast mirrors
- Optional equipment like air conditioners and other electronically powered accessories
- Road composition (concrete, asphalt, gravel, dirt etc)
- Road condition (dry, wet, icy, snow etc)
- Incline (mileage decreases with every degree of upslope)
- Weight (150lbs per person; cargo (luggage, golf clubs etc)
- Special equipment such as HD A/Cs, HD axles, or larger fuel tanks (add 6 pounds of additional weight per gal)
- Outside temperature

Additional Resources

- For information on fuel economy, emissions, etc. including ratings on various car types visit: http://www.fueleconomy.gov and http://www.weather.com/activities/driving/greenvehicle/?from=drivfl .

Reproducible

Miscellaneous Facts About CO_2 Emissions and Global Warming

The burning of fossil fuels (coal, oil, natural gas, etc.) has been linked to global warming. While the relationship itself is generally agreed upon, the long-term effects of it are not.

- When we burn fossil fuels, we create carbon dioxide. This CO_2 is emitted into the Earth's atmosphere. When solar rays pass through our atmosphere and hit the Earth, they become infrared rays and bounce back toward the atmosphere. These infrared rays are heat. Carbon dioxide prohibits these infrared rays from passing back through the atmosphere, however. Thus, carbon dioxide in the atmosphere traps heat. Fundamentally, this is a beneficial process as it keeps the Earth's temperature at a level that allows for life to exist. But the question is – do we now have too much of a good thing?

- Some speculate that this trapping of heat could cause the polar ice caps to melt, which in turn could cause flooding of coastal cities. Others suggest that it may cause changes in weather patterns resulting in the accumulation of water on the Earth's surface. This could consequently lead to increased breeding grounds for mosquitoes, which might cause malaria. Still others speculate that global warming could cause other parts of the planet to dry up, making farming much more difficult in some areas.

- The amount of carbon dioxide that enters the atmosphere is counteracted by its *fixation* by natural processes (i.e. it is held out of the atmosphere for an extended period of time by these processes.) For example, trees fix carbon dioxide to create food through photosynthesis. But when we cut down trees, they decompose and give off carbon dioxide and thus no longer fix it for food.

- An interesting dilemma faced by scientists is exactly where all of the excess carbon dioxide created by humans is going. Some believe it is being stored in the shells of marine organisms and when they die is sinking to the bottom of the ocean where it is being stored long term.

Lesson 5: Personal Energy Consumption Audit

Audience:
Grades 9 – 12

Lesson Overview:
In this assignment, students will examine their own family's personal energy consumption habits and the impacts of those habits on the environment. They will start by determining how much power various appliances around their homes consume. Then they will calculate the approximate monthly cost of operating each appliance based on the cost of electricity. Having a thorough understanding of the dynamics of their own practices will provide a natural transition to understanding the energy dynamics at community, national, and global levels. Students will also see how positive changes at an individual level can be amplified to the same degree to help reverse the trend of deterioration.

Objectives:

- To apply important terminology and formulas associated with electrical energy use.
- To study a number of appliances to analyze their relative contribution to household energy bills.
- To examine personal energy consumption habits and understand the impacts of those habits on the environment.

National Standards Addressed

Science as Inquiry
CONTENT STANDARD A
As a result of activities in grades 9 - 12, all students should develop:

- Abilities necessary to do scientific inquiry.
- Understandings about scientific inquiry.

Life Science
CONTENT STANDARD F:

- Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.

Desired Outcomes:

After completing this lesson, students will:

- Make the connection between electrical consumption, economics, and environment
- Share new knowledge and methods that emerge from different types of investigations and public communication similar to those of scientists.
- By communicating and defending the results of scientific inquiry, students will develop presentation skills that are logical and which identify the connections between natural phenomena, their investigations, and the historical body of scientific knowledge.
- Become conscious of the need to clearly track, identify, cite and record the methods and procedures used in scientific investigation. This will enable further investigation to continue without loss of time or resources.
- Use mathematical tools and models to guide and improve the posing of questions, gathering data, constructing explanations, and communicating results.

Teacher Prep Time:

Minimal

Class Time:

Three 90-minute class periods

Materials Needed:

To be determined by students

Background:

The combustion of fossil fuels to produce electricity accounts for about one-third of all CO_2 emissions in the world today. Most people in the United States get their electricity from the burning of coal. Because of its high carbon content, coal emits approximately .77 kg of CO_2 per kilowatt (kW) produced, much higher than that of either oil or natural gas (about .75 kg of CO_2 are given off per kilowatt (kW) produced by other sources.) Sulfur Dioxide (SO_2) – another by-product of coal burning – is also a primary pollutant source for acid deposition. Since there are no economically feasible methods to make CO_2 environmentally benign, the only way to reduce its emission is to reduce production and consumption.

Prior to beginning this lesson, you may need to explain the concept of kilowatt hour (kWh) to your students. Utility companies report the quantity of electricity that we use in terms of kilowatt-hours. One kilowatt equals 1,000 watts. Appliances all have markings

to designate "wattage." Wattage is the number of watts that are used in one hour: i.e. If 1,000 watts (1 kilowatt) of power is used for 1 hour, that is a kilowatt-hour (kWh). If we can determine how much electricity costs per kilowatt-hour, we can estimate our bills and determine which appliances cost us the most both monetarily and environmentally speaking. For instance, we will discover that appliances that convert electricity to heat use more kilowatt-hours than others.

Lesson Steps:

Part 1: Calculate cost of appliance use

1. This activity will require the students to conduct a mini-audit of the appliances used in their individual homes in order to determine their electrical consumption per month. To do so, students will need to consider:
    - What appliances are used on a daily basis in my home?
    - How much does it cost to watch television for an hour?
    - How much energy does it take to cook a meal, heat a house, or light a lamp?
    - What does that energy cost?
    - Does it take more energy to toast bread or to boil water?
    - What are the major and minor energy users in your home?
    - How much does it cost to use the various appliances per hour, day, or year?
    - Are they worth that amount?
2. Provide the reproducible for calculating appliance costs.
3. Have students provide their calculations in a table format reflecting each appliance used and the total estimated amount used by their household for a month. Remind students not to forget to include light bulbs!

Part 2: Determine carbon dioxide released

1. Using their tables, students should multiply the number of KWh for each appliance by 0.77 kg/kWh to determine the amount of carbon dioxide emitted (assuming coal is the primary source for energy.) Students should also calculate the total amount released by their household energy consumption for one month.
2. Students should then calculate an estimated annual total for the amount of carbon dioxide emitted by their households' power consumption.
3. Optional: If a coal burning power plant is the main source for the student's electricity, multiplying the number of kWh by 0.32 kg/kWh can approximate the amount of SO2 emitted as well.

Part 3: Summarize utility usage for the year

1. Students should gather as many utility bills for the year as possible. Using this information, have students create another table recording their household's actual monthly kWh usage across the year. As an alternative, students could read the electric meter in their household at the same time of day for 14 days and record the values in a table.

2. Next, instruct students to calculate the average kWh usage per month. If some months vary greatly, students should include notes regarding average temperature for those time periods and note any special appliances that were used (such as air conditioning, extra fans, humidifier, etc).

Part 4: Prepare a report

1. To summarize their findings, students should create a graphical representation of their electrical usage estimates for one month and one year.
2. Using the tables they have created, students should then prepare a report that analyzes their own personal energy consumption and identifies ways to reduce emissions of carbon dioxide and sulfur dioxide from their own lives.

Part 5: Conclusion and discussion

1. Have multiple students present their findings to see if similar results were obtained across the class.
2. As a class, identify lifestyle changes that might lead to more environmentally desirable results.

Academic Extensions/Modifications

Ask students to prepare a position paper that will be presented to the class. The paper should outline steps that might be taken to decrease environmental damage from the perspective of other world citizens. For instance, a Pakistani farmer may have very different energy consumption patterns than an American computer programmer.

Additional Resources

For more detailed steps on conducting a personal energy audit, visit: http://www.enviroliteracy.org/pdf/labnrg1.pdf .

Method for Calculating Monthly Appliance Cost

1. Determine the power used by the appliance: P=VI (P = power measured in watts)
   To do so, find the label that has the wattage rating on the appliance. If it is not listed, calculate wattage by multiplying the Amperage (I) rating times the Voltage (v), usually 110 v or 220 v. You may need to refer to the owner's manual or call an appliance store or dealer. Many utilities can also supply this information.

2. Determine the energy consumed by each appliance. E=P*t (Energy = Power * time)
   To do so, multiply the Wattage (P) by the average hours per day that the appliance is used.

3. Multiply the value from step 2 by 30 (number of days in a month) to calculate the total power used by the appliance in a month.

4. Divide this value (step 3) by 1000 to get kWh. *

5. Multiply the number of kWh by the cost of electricity. (You can calculate this value from a utility bill or by calling your local power company.)

* Note: To calculate the consumption of a hot water heater, use the following formula:
kWh per month = N (2 ΔT – 17.6) where N = number of people in the home, ΔT is the difference between cold tap water and the hottest water from the tap in Fahrenheit.