IT'S OUR AIR

It's Our Air!

HIGH SCHOOL AIR QUALITY EDUCATION

CURRICULUM & TEACHER GUIDE

A QUICK START RESOURCE

IT'S OUR AIR

WELCOME TO *IT'S OUR AIR!*

North Carolina Air Quality

FREE Web-based

High School Earth & Environmental Science

Bring the science of air pollution to life in your classroom.

It's Our Air is a web-based, North Carolina, high school, air quality curriculum. The curriculum's 15 engaging activities and 9 dynamic videos cover air pollution, health, forecasting, solutions, and more. And while students are learning about air quality, they also learn how to gather and analyze data, graph, read about science, and other key skills. Best of all, it's provided to you at no-cost.

This **Curriculum and Teacher Guide** is designed to be a quick start manual and introduction to the *It's Our Air* high school air quality curriculum. Inside, you will find an overview of the curriculum and lots of other information to help you get started using these activities and videos with your students. There are several sample activities as well.

The website, www.itsourair.org, has even more information to help you get started, like Teacher to Teacher (T2T) videos with tips on how to successfully implement these activities in your classroom.

We invite you to explore this **Curriculum and Teacher Guide** and our website. It's the best way to find the combination of *It's Our Air* activities and videos that will work best for you and your students.

Engaging Interactive Hands On

Learn more at www.itsourair.org

IT'S OUR AIR

It's Our Air is a free, North Carolina-specific curriculum that includes a series of activities and videos focused on air quality for the state's high school level Earth and Environmental Science teachers and educators to use with their students. *It's Our Air* is designed to help students develop a better understanding of the science and technology that helps us explain, monitor, predict and protect air quality. While teaching students about air quality, the curriculum also teaches students how to gather and analyze data, graph, measure, and other skills that will help prepare students for all the required sciences they will take throughout high school. *It's Our Air* engages students in learning the science of air quality using a variety of hands-on activities and dynamic video segments. The activities and videos provide a comprehensive curriculum that can be used as is or adapted by teachers to fit their course needs, with teachers picking and choosing from the various activities and videos. The *It's Our Air* project was originated through a collaboration of educators, industry, environmental groups and the North Carolina Division of Air Quality (DAQ). *It's Our Air* is currently a project of and is operated by the DAQ and its NC Air Awareness program. Please see the acknowledgments page at www.itsourair.org/acknowledgments for a detailed list of the contributors to this project.

NC DIVISION OF AIR QUALITY MISSION

The Division of Air Quality works with the state's citizens to protect and improve outdoor, or ambient, air quality in North Carolina for the health, benefit and economic well-being of all. To carry out this mission, the DAQ operates a statewide air quality monitoring network to measure the level of pollutants in the outdoor air; develops and implements plans to meet future air quality initiatives; assures compliance with air quality rules; and educates, informs and assists the public with regard to air quality issues. The NC Division of Air Quality is a division of the NC Department of Environmental Quality. The NC Department of Environmental Quality's (DEQ) primary mission is to protect North Carolina's environment. In its essence, DEQ is a service organization. A collaborative stewardship among the citizens, government regulators and the business community will maintain and enhance North Carolina's environment and natural resources for the benefit and enjoyment of everyone living in or visiting our great state.

NC AIR AWARENESS

The NC Air Awareness is a public outreach and education program of the North Carolina Division of Air Quality (DAQ). The goal of the program is to reduce air pollution though voluntary actions by individuals and organizations. The program seeks to educate individuals about the sources of air pollution and explain how the health effects of air pollution can be minimized by modification of outdoor activities on ozone action days. In addition, the program aims to inform the public of ways to minimize production of air pollutants to improve air quality over time. DAQ works closely with local air agencies, councils of government, non-profits, and various stakeholders to accomplish program goals. The program utilizes a wide range of web and media outlets to broadcast our message to the general public. These include statewide communication about idle reduction, clean air tips, air quality action day information, open burning, and much more. Learn more about NC Air Awareness at www.ncair.org.

Contact

NC Department of Environmental Quality
NC Division of Air Quality
Attn: NC Air Awareness program

Physical Address

217 West Jones Street
Raleigh, NC 27603

Mailing Address

1641 Mail Service Center
Raleigh, NC 27699-1601

ncair.org
919-707-8400
Air.awareness@www.ncdenr.gov

NC[SM]

Air Quality
ENVIRONMENTAL QUALITY

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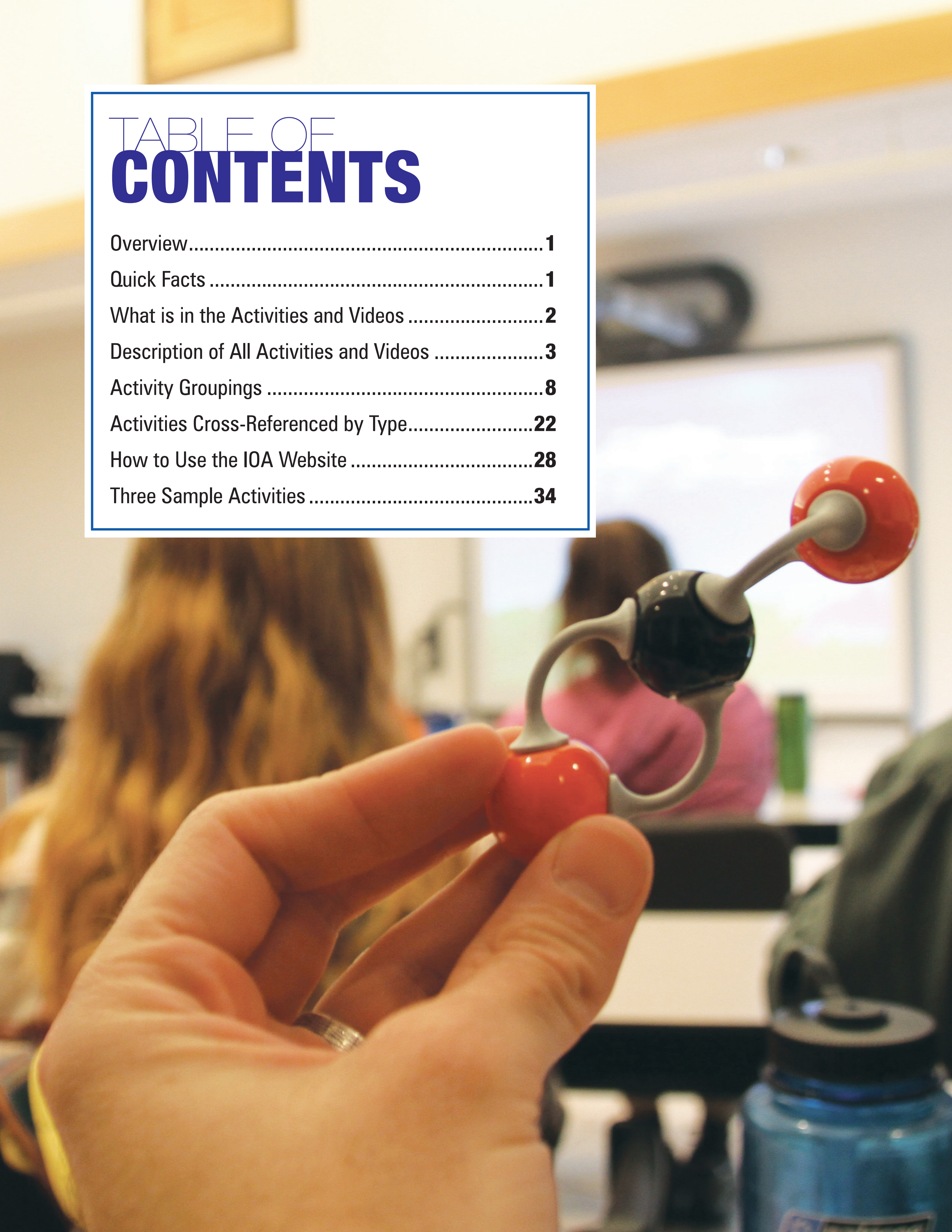


OVERVIEW

It's Our Air is a FREE air-quality curriculum for North Carolina Earth and Environmental Science classes. All the teaching materials for *It's Our Air* are located on our website at www.itsourair.org.

Whether you have a few days or a few weeks to explore air quality, you can use *It's Our Air* to engage your students with fun and meaningful learning that is aligned with the North Carolina Essential Standards and will help you meet your teaching and professional goals.

The curriculum consists of hands-on activities and videos designed to help students understand the science and technology used to monitor, predict, protect, and communicate about air quality.

The curriculum is organized in three modules:

- Module 1: Air Pollutants and Their Sources (7 activities, 4 videos)
- Module 2: Predicting Air Pollution (3 activities, 1 video)
- Module 3: Air Pollution Problems and Solutions (5 activities, 4 videos)

Use the whole curriculum start to finish – or pick and choose according to your needs.

We've included tips from an award-winning Earth Science teacher to help you choose which activities to do and how to implement them successfully.

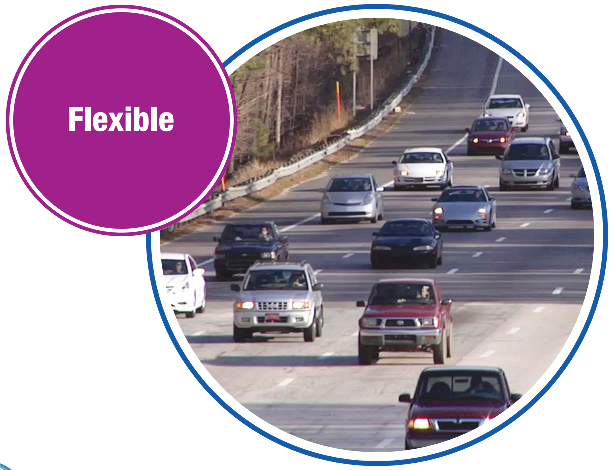
The inquiry-based curriculum introduces students to air-quality concepts, and to the methods scientists use to learn about the world.

The curriculum is a perfect addition to any STEM classroom.

It's Our Air is a program of the North Carolina Air Awareness Program of the Division of Air Quality, whose goal is to reduce air pollution through voluntary actions by individuals and organizations.

IT'S OUR AIR QUICK FACTS

- 15 inquiry-based activities
- Most activities take one block period or less
- 9 dynamic videos
- Aligned to North Carolina Earth Science standards
- Includes North Carolina information and resources
- Meets the needs of a variety of learning styles
- Can be used in Earth Science classes or AP Environmental Science
- Field-tested by an award-winning Earth Science teacher
- Available free for download on itsourair.org



WHAT IS IN THE ACTIVITIES AND VIDEOS

ACTIVITIES

The activities contain all of the information you need, including background content for you and Student Pages to photocopy and hand out. The materials needed for each activity are included (for example: datasets or maps) or they are commonly available in a high school classroom (for example: beakers, thermometers, art supplies, internet connection). To quickly see what materials are needed for a particular activity, go to that activity's page on the website (itsourair.org).

Here's the format for each activity:

- Summary
- Essential Questions
- Time Needed
- North Carolina Essential Standards for Earth/Environmental Science
- Making Connections (linking to concepts from other subjects or daily life)
- Background (content information for the teacher)
- Materials list
- Video Description (for those activities with videos)
- Teacher Tips (suggestions from an award-winning teacher)
- Warm Up (preparing students for the activity)
- The Activity (with answer keys)
- Wrap Up and Action(helping students integrate what they've learned)
- Assessment (ideas that go beyond tests)
- Extensions (suggestions for exploring this topic further)
- Resources (websites for more information)
- Student Pages (to guide students through the activity)

Module 1: Activity 1

What is Air?

IT'S OUR AIR

SUMMARY

The first step in learning about air pollution is learning about air. Through a variety of hands-on experiences presented as stations in the classroom, students will discover properties of air, including that air has volume, mass, and pressure; that it is compressible; and that it expands when heated. They will also learn about the major molecular components of our atmosphere (nitrogen, oxygen, argon), the four layers of our atmosphere, and that air contains water vapor.

ESSENTIAL QUESTIONS

- What is air made of?
- What are some of the properties of air?
- How can we demonstrate those properties when air is invisible?
- Is our atmosphere homogenous or does it change with elevation?

TIME NEEDED

One class period plus 20 minutes of setup and review/assessment on the next day.

North Carolina ESSENTIAL STANDARDS FOR EARTH/ENVIRONMENTAL SCIENCE

- EEn.2.3.1 Explain how water is an energy agent (currents and heat transfer).
- EEn.2.5.1 Summarize the structure and composition of our atmosphere.
- EEn.2.5.5 Explain how human activities affect air quality

A product of the NC Air Awareness Program 2014.
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www.itsourair.org

VIDEOS

The videos, produced specifically to accompany the *It's Our Air* activities, are narrated by an engaging host who interacts with a diverse group of high school students on set and around North Carolina – from the mountains to the coast. The videos expose students to experiences that would be difficult or impossible to have in the classroom, including interviews with a wide variety of experts, demonstrations using scientific equipment, and virtual field trips, such as a guided tour of an air monitoring station. The videos also contain animated illustrations to help explain challenging topics.

MODULE 1: AIR POLLUTANTS AND THEIR SOURCES

7 activities and 4 videos covering the basic science of air quality including: properties of air, combustion, the criteria pollutants, local and regional pollution data, and detecting ozone and particulate matter.

1-1 WHAT IS AIR? (ACTIVITY & VIDEO)

Through a video and a variety of hands-on experiences presented as stations in the classroom, students will discover properties of air, including that air has volume, mass, and pressure; that it is compressible and that it expands when heated. They will also learn about the major molecular components of our atmosphere (nitrogen, oxygen, argon), the four layers of our atmosphere, and that air contains water vapor.

1-2 COMBUSTION EQUATIONS (ACTIVITY & VIDEO)

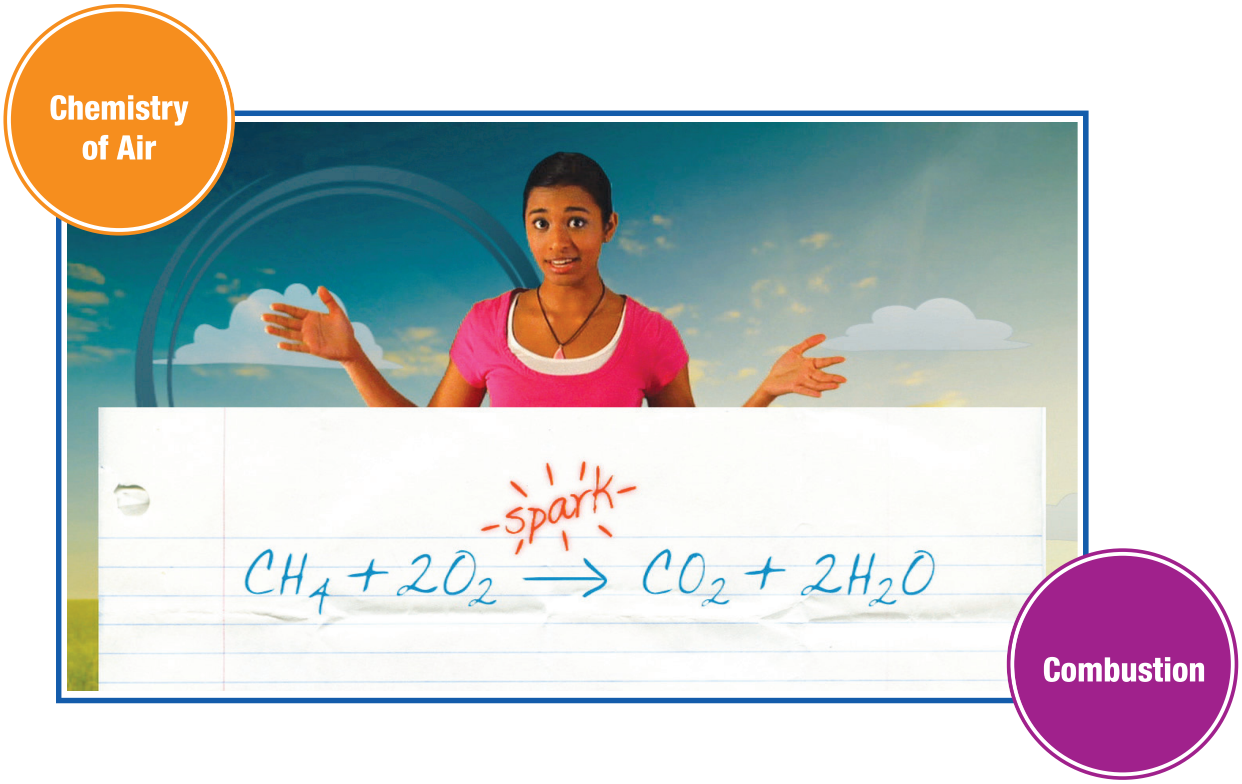
A video introduces the concept of combustion as a chemical reaction and illustrates how combustion causes the rearrangement of atoms into new molecules. Air pollution can result when other gases in our atmosphere and substances in fuel are added into the combustion mix. In the activity, students use molecular model sets to become familiar with some simple chemical equations describing combustion and to see how the burning of fossil fuels produces carbon dioxide.

1-3 PARTS PER MILLION (ACTIVITY)

In the activity, students will develop an understanding of the terms parts per million (ppm) and parts per billion (ppb) by systematically diluting a solution of food coloring (or milk) and water. They will convert ratios to percentages to ppm to ppb. They will correlate the ratios they've created in the classroom to the ratios of various gases in our atmosphere.

1-4 CRITERIA POLLUTANTS AND A CLOSER LOOK AT OZONE (ACTIVITY & VIDEO)

In the video experts are asked, "How do you define air pollution?" The video then reviews the criteria pollutants: ground-level ozone, particulate matter, nitrogen oxides, sulfur dioxide, carbon monoxide, and lead. In the activity, students will be introduced to the criteria pollutants and will work in groups to make cartoon booklets demonstrating the formation of ground-level ozone and the destruction of stratospheric ozone.



1-5 LOCAL SOURCES OF AIR POLLUTION (ACTIVITY & VIDEO)

In the video, students will hear from experts in the North Carolina mountains, piedmont and coastal plain to learn about air pollution issues including ground-level ozone, particulate matter (PM), acid deposition, mercury deposition, and nitrogen deposition. In the activity, students will learn the sources of some common air pollutants by making pie charts showing the main sources of PM2.5, PM10, nitrogen dioxide and sulfur dioxide for the United States as a whole, their state, and their county.

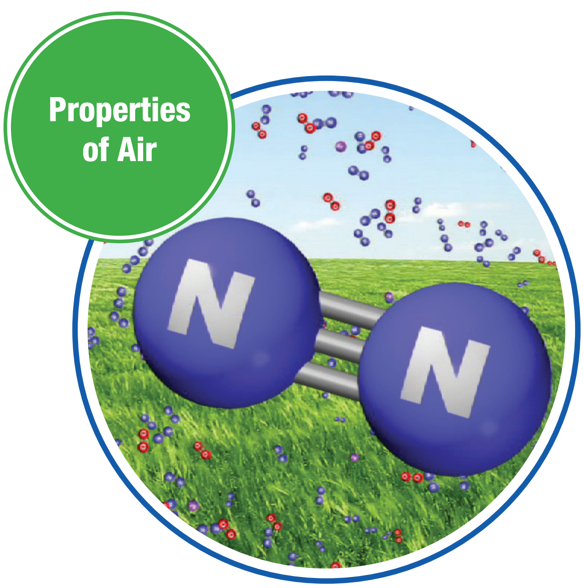
1-6 MAKING AND USING OZONE INDICATORS (ACTIVITY)

In this classroom and outdoor activity, students check for the presence and relative amounts of ozone in the air on their school campus using Schoenbein strips they make with filter paper, cornstarch, and potassium iodide.

1-7 SAMPLING PARTICULATE MATTER (ACTIVITY)

In this classroom and outdoor activity, students will sample particulate matter around town or campus and compare the results. They will also gather particulate matter from tailpipe emissions and compare different types of vehicles (e.g., cars, buses).

Local & NC Air Pollution



MODULE 2: PREDICTING AIR POLLUTION

3 activities and 1 video exploring the science of predicting air pollution including: the air quality index, developing a model to predict ground-level ozone, and air quality monitoring forecasting. The video is paired with Activity 2-3 but is designed to work well with any of the Module 2 activities.

2-1 WHAT'S AN AIR QUALITY INDEX? (ACTIVITY)

In this activity, students will learn how to interpret the Air Quality Index (AQI) and identify seasonal patterns for ozone and particulate matter in their region.

2-2 MAKING A SIMPLE PREDICTIVE MODEL FOR GROUND-LEVEL OZONE POLLUTION (ACTIVITY)

In this activity, students will use pollution and meteorology data from North Carolina to explore the relationship between ground-level ozone pollution and (1) temperature, (2) solar radiation, (3) wind speed, and (4) precipitation. Students will make a simple predictive model based on what they learn from these data.

2-3 FORECASTING AIR QUALITY (ACTIVITY & VIDEO)

The video introduces methods used to monitor, predict, and report air pollution, and includes interviews with meteorologists. In the activity, students will use archived weather maps, satellite images, forecast models, and data to put together an ozone forecast for a particular day in Charlotte, North Carolina. They will then check their forecast against the actual ozone levels for that day.

MODULE 3: AIR POLLUTION PROBLEMS AND SOLUTIONS

5 activities and 4 videos introducing possible solutions to our air quality problems including: scientific research, personal energy and driving choices, technology solutions, energy efficiency, alternative energy, and regulations.

3-1 SCIENTIFIC LITERACY: HEALTH PROBLEMS AND AIR POLLUTION (ACTIVITY & VIDEO)

The video takes an in-depth look at the types of scientific research that help us understand problems caused by ozone and particulate matter. In the scientific literacy activity, students will read and explain articles and scientific papers about the effects of ozone and particulate matter on human health.

3-2 PERSONAL CHOICES AT HOME TO PREVENT AIR POLLUTION (ACTIVITY & VIDEO)

The video introduces the personal and societal choices available to solve our air pollution problems. In the activity, students learn about choices they can make at home to have the greatest impact on improving air quality. They also learn which appliances and electronics use the most and least electricity.

3-3 DRIVING CHOICES: CALCULATING CAR EMISSIONS (ACTIVITY & VIDEO)

The video takes an in-depth look at ways drivers can improve air quality. In the activity, students use data from EPA websites to compare the emissions of nitrogen oxides and sulfur dioxide from several different cars, including an all-electric vehicle.

3-4 THE CLEAN AIR ACT & NORTH CAROLINA CLEAN SMOKESTACKS ACT (ACTIVITY & VIDEO)

The video describes the North Carolina Clean Smokestacks legislation and its success in improving air quality. In the activity, student groups will research how air quality has improved since the passage of the Clean Air Act (CAA), and evaluate historical documents and other media from three events that set the stage for the CCA.

3-5 RESEARCH AND ACTION: COMMUNITY AIR QUALITY PROJECT (ACTIVITY)

In this activity, students will integrate and synthesize what they've learned in It's Our Air by choosing, designing, carrying out, and evaluating a school-wide or community project involving research, stewardship, and/or education.

ACTIVITY GROUPINGS

HOW LONG DOES *IT'S OUR AIR* TAKE? YOU DECIDE!

It's Our Air can be used in a variety of ways depending on how much time you have available and what topics you want to cover. We've come up with some suggested groupings, but feel free to design your own as well, using the table below that shows how long each activity takes.

- The groupings listed in this section take anywhere from three days to three weeks. (These groupings are based on block periods, so if you use shorter periods the groupings will take longer.)
- Some groupings are designed to cover the basics of air quality and air pollution in North Carolina in a specific amount of time: one week, two weeks, or three weeks.
- Other groupings focus on specific themes: ozone, particulate matter, North Carolina air quality, literacy, creativity and design, data analysis and modeling, meteorology, vehicles, choices at home, and policy issues. Most of these take from 3-4 days (again, using block periods).
- If you do the entire curriculum, it will take about four weeks (20 block periods).
- Many of the activities lend themselves to flipping the classroom; consider having students watch the videos and/or complete other elements of the activities the night before.
- All of the groupings allow you to cover the desired air-quality topics in the most efficient way, making the most of valuable classroom time.

FULL *IT'S OUR AIR* CURRICULUM

Time Needed for Each Activity: 1 day = 1 block period = approx. 90 minutes

MODULE 1		
1-1	What is Air?	135 min. (1½ days)
1-2	Combustion Equations	45 min. (½ day)
1-3	Investigating Parts Per Million, Drop by Drop	45-60 min. (½ day)
1-4	Criteria Pollutants and a Closer Look at Ozone	90-135 min. (1-1½ days)
1-5	Local Sources of Air Pollution	90 min. (1 day)
1-6	Making and Using Ozone Indicators	90 min. (1 day)
1-7	Sampling Particulate Matter	90 min. (1 day)
MODULE 2		
2-1	What's an Air Quality Index?	90 min. (1 day)
2-2	Making a Simple Predictive Model for Ground-Level Ozone	135 min. (1½ days)
2-3	Forecasting Air Quality	90 min. (1 day)
MODULE 3		
3-1	Scientific Literacy: Health Problems and Air Pollution	90 min. (1 day)
3-2	Personal Choices at Home to Prevent Air Pollution	180 min. (2 days)
3-3	Driving Choices: Calculating Car Emissions	180 min. (2 days)
3-4	The Clean Air Act	180 min. (2 days)
3-5	Community Air Quality Project	180-270 min. (2-3) days

TIMED-BASED GROUPINGS FOR EARTH SCIENCE

1 day = 1 block period = approx. 90 minutes

ONE WEEK FOR EARTH SCIENCE

Air pollution and air quality in North Carolina

In one week of block periods, you can introduce your students to the six criteria (or common) air pollutants, with a focus on ozone and particulate matter, which are air pollutants of particular concern in North Carolina. Students will create comic books, posters, ozone indicator strips, and particulate matter collectors in this set of hands-on activities.

ONE WEEK	
Day 1	**Video 1-1:** (Parts 1 & 2): What is Air? **Activity 1-1**: What is Air?
Day 2	**Video 1-2**: Combustion **Video 1-4**: The Criteria Pollutants Start **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 3	Finish **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 4	**Video 1-5**: Air Pollution in North Carolina Start **Activity 1-5**: Local Sources of Air Pollution Start **Activity 1-6**: Making and Using Ozone Indicators Start **Activity 1-7**: Sampling Particulate Matter (See special intructions for more info on these three activities.)
Day 5	Finish **Activity 1-5**: Local Sources of Air Pollution Finish **Activity 1-6**: Making and Using Ozone Indicators Finish **Activity 1-7**: Sampling Particulate Matter (See special intructions for more info on these three activities.)

SPECIAL INSTRUCTIONS **FOR DAYS 4 AND 5**

You may notice that some of the groupings on these pages call for completing three activities (1-5, 1-6, and 1-7) on Days 4 and 5. Here's how (for block periods):

Day 4 – As a demo, prepare the ozone solution in a single 100 ml beaker to paste all the ozone strips, while class cuts filter paper into strips (1-6) and makes particulate cards (1-7) in groups. Have students hang both the ozone filters and the particulate matter cards outside. Next, begin Activity 1-5 (45 min). End by watching video 1-5 about sources of pollution (10 minutes).

Day 5 – Collect the ozone strips and particulate cards and have students answer questions on Student Pages for Activities 1-6 and 1-7 (30-45 minutes). Next, have students finish the pie charts from Activity 1-5 and write a brief summary (30-45 minutes). Use the last 15 minutes of class for student presentations.

These two days may be a tight squeeze for lower performing classes. Have all materials for Activities 1-6 and 1-7 ready ahead of time and provide students with circle templates to make the pie charts go faster.

TWO WEEKS FOR EARTH SCIENCE

Exploring air pollution, North Carolina air quality, and ways to improve air quality

This two-week grouping touches on all the major topics, with some opportunity for data analysis. This grouping incorporates the Community Air Quality Project (3-5), but turns it into an in-class writing assignment to save time.

WEEK 1	
Day 1	**Video 1-1:** (Parts 1 & 2): What is Air? **Activity 1-1**: What is Air?
Day 2	**Video 1-2**: Combustion **Video 1-4**: The Criteria Pollutants Start **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 3	Finish **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 4	**Video 1-5**: Air Pollution in North Carolina Start **Activity 1-5**: Local Sources of Air Pollution Start **Activity 1-6**: Making and Using Ozone Indicators Start **Activity 1-7**: Sampling Particulate Matter (See special intructions for more info on these three activities.)
Day 5	Finish **Activity 1-5**: Local Sources of Air Pollution Finish **Activity 1-6**: Making and Using Ozone Indicators Finish **Activity 1-7**: Sampling Particulate Matter (See special intructions for more info on these three activities.)

WEEK 2	
Day 1	Do parts B and C of **Activity 2-1**: What's an Air Quality Index? **Video 2-3:** Forecasting Air Quality
Day 2	**Video 3-1:** Scientific Research and Air Quality **Activity 3-1:** Scientific Literacy: Health Problems and Air Pollution
Day 3	**Video 3-2**: Introduction to Energy Solutions/Energy Choices Do parts A and C of **Activity 3-2**: Personal Choices at Home to Prevent Air Pollution
Day 4	**Video 3-3:** Driving Choices and Air Pollution **Activity 3-3:** Driving Choices: Calculating Car Emissions
Day 5	Modify **Activity 3-5**: Research and Action: Community Air Quality Project as an in-class writing assignment (What is the biggest problem with NC air? What could we do individually or together to improve it?)

THREE WEEKS FOR EARTH SCIENCE

Air pollution, North Carolina air quality, and ways to improve air quality

Three weeks of block periods allows you to cover most of the curriculum, giving your students an in-depth look at air quality and air pollution in North Carolina. Students will learn about ways human activities impact the environment and how air pollution affects our health through a variety of hands-on and data-rich activities.

WEEK 1	
Day 1	**Video 1-1:** (Parts 1 & 2): What is Air? **Activity 1-1**: What is Air?
Day 2	**Video 1-2**: Combustion **Video 1-4**: The Criteria Pollutants Start **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 3	Finish **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 4	**Video 1-5**: Air Pollution in North Carolina Start **Activity 1-5**: Local Sources of Air Pollution Start **Activity 1-6**: Making and Using Ozone Indicators Start **Activity 1-7**: Sampling Particulate Matter (See special intructions for more info on these three activities.)
Day 5	Finish **Activity 1-5**: Local Sources of Air Pollution Finish **Activity 1-6**: Making and Using Ozone Indicators Finish **Activity 1-7**: Sampling Particulate Matter (See special intructions for more info on these three activities.)

WEEK 2	
Day 1	**Activity 2-1:** What's an Air Quality Index?
Day 2	**Video 2-3:** Forecasting Air Quality **Activity 2-3:** Forecasting Air Quality
Day 3	**Video 3-1**: Scientific Research and Air Quality **Activity 3-1**: Scientific Literacy: Health Problems and Air Pollution
Day 4	**Video 3-2:** Introduction to Energy Solutions/Energy Choices Start **Activity 3-2:** Personal Choices at Home to Prevent Pollution
Day 5	Finish **Activity 3-2**: Personal Choices at Home to Prevent Pollution

WEEK 3	
Day 1	**Video 3-3:** Driving Choices and Air Pollution Start **Activity 3-3:** Driving Choices: Calculating Car Emissions
Day 2	Finish **Activity 3-3:** Driving Choices: Calculating Car Emissions Start **Activity 3-5:** Research and Action: Community Air Quality Project
Day 3	Work on **Activity 3-5:** Research and Action: Community Air Quality Project
Day 4	Work on **Activity 3-5:** Research and Action: Community Air Quality Project
Day 5	Finish **Activity 3-5**: Research and Action: Community Air Quality Project

TIMED-BASED GROUPINGS FOR AP ENVIRONMENTAL SCIENCE

1 day = 1 block period = approx. 90 minutes

ONE WEEK FOR AP ENVIRONMENTAL SCIENCE

Exploring air pollution, North Carolina air quality, and air quality regulation

This one-week grouping quickly covers information about ozone, particulate matter and the other criteria pollutants, allowing time for activity 3-4 on the Clean Air Act, which students will need to know for the AP exam.

ONE WEEK	
Before Day 1	*Homework*: Watch **Video 1-1:** (Parts 1&2): What is Air? Do Layers of the Atmosphere worksheet from **Activity 1-1:** What is Air?
Day 1	**Video 1-2:** Combustion **Activity 1-2:** Combustion Equations Start **Activity 1-4:** Criteria Pollutants and a Closer Look at Ozone *Homework*: **Video 1-4:** The Criteria Pollutants and work on comics
Day 2	Finish **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 3	**Activity 1-5: Local Sources of Air Pollution** **Homework: Read articles for Activity 3-1: Scientific Literacy: Health Problems and Air Pollution**
Day 4	Finish **Activity 3-1**: Scientific Literacy: Health Problems and Air Pollution Start **Activity 3-4**: The Clean Air Act
Day 5	Finish **Activity 3-4**: The Clean Air Act **Video 3-4**: North Carolina Clean Smokestacks Act

SPECIAL INSTRUCTIONS **FOR DAYS 4 AND 5**

You may notice that some of the groupings on these pages call for completing three activities (1-5, 1-6, and 1-7) on Days 4 and 5. Here's how (for block periods):

Day 4 – As a demo, prepare the ozone solution in a single 100 ml beaker to paste all the ozone strips, while class cuts filter paper into strips (1-6) and makes particulate cards (1-7) in groups. Have students hang both the ozone filters and the particulate matter cards outside. Next, begin Activity 1-5 (45 min). End by watching video 1-5 about sources of pollution (10 minutes).

Day 5 – Collect the ozone strips and particulate cards and have students answer questions on Student Pages for Activities 1-6 and 1-7 (30-45 minutes). Next, have students finish the pie charts from Activity 1-5 and write a brief summary (30-45 minutes). Use the last 15 minutes of class for student presentations.

TWO WEEKS FOR AP ENVIRONMENTAL SCIENCE

Exploring air pollution, North Carolina air quality, air quality regulation, and ways to improve air quality

This two-week grouping covers major topics related to air pollution, with a North Carolina focus, and includes opportunities for data analysis. Compared to the two week grouping for Earth Science, it focuses on topics that students will need to know for the AP exam, including the Clean Air Act.

WEEK 1	
Day 1	**Video 1-1:** (Parts 1 & 2): What is Air? **Activity 1-1**: What is Air?
Day 2	**Video 1-2**: Combustion **Video 1-4**: The Criteria Pollutants Start **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 3	Finish **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 4	**Video 1-5**: Air Pollution in North Carolina Start **Activity 1-5**: Local Sources of Air Pollution Start **Activity 1-6**: Making and Using Ozone Indicators Start **Activity 1-7**: Sampling Particulate Matter (See special intructions for more info on these three activities.)
Day 5	Finish **Activity 1-5**: Local Sources of Air Pollution Finish **Activity 1-6**: Making and Using Ozone Indicators Finish **Activity 1-7**: Sampling Particulate Matter (See special intructions for more info on these three activities.)

WEEK 2	
Day 1	Do parts B and C of **Activity 2-1**: What's an Air Quality Index? **Video 2-3:** Forecasting Air Quality
Day 2	**Video 3-1:** Scientific Research and Air Quality **Activity 3-1:** Scientific Literacy: Health Problems and Air Pollution *Homework*: **Video 3-2**: Introduction to Solutions/Energy Choices
Day 3	Do Parts A and C of **Activity 3-2**: Personal Choices at Home to Prevent Air Pollution **Video 3-3**: Driving Choices and Air Pollution Start **Activity 3-3**: Driving Choices: Calculating Car Emissions
Day 4	Finish **Activity 3-3**: Driving Choices: Calculating Car Emissions (skipping part C if time is short) Start **Activity 3-4**: The Clean Air Act
Day 5	Finish **Activity 3-4**: The Clean Air Act **Video 3-4**: North Carolina Clean Smokestacks Act

THREE WEEKS FOR AP ENVIRONMENTAL SCIENCE

Air pollution, North Carolina air quality, air quality regulation, and ways to improve air quality

This grouping covers almost the entire curriculum, including opportunities for data analysis, modeling, and forecasting. It covers topics students will need to know for the AP exam, including the Clean Air Act.

WEEK 1	
Day 1	**Video 1-1:** (Parts 1 & 2): What is Air? **Activity 1-1**: What is Air?
Day 2	**Video 1-2**: Combustion **Video 1-4**: The Criteria Pollutants Start **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 3	Finish **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 4	**Video 1-5**: Air Pollution in North Carolina Start **Activity 1-5**: Local Sources of Air Pollution Start **Activity 1-6**: Making and Using Ozone Indicators Start **Activity 1-7**: Sampling Particulate Matter (See special intructions for more info on these three activities.)
Day 5	Finish **Activity 1-5**: Local Sources of Air Pollution Finish **Activity 1-6**: Making and Using Ozone Indicators Finish **Activity 1-7**: Sampling Particulate Matter (See special intructions for more info on these three activities.)

WEEK 2	
Day 1	Do parts B and C of **Activity 2-1**: What's an Air Quality Index? **Video 2-3:** Forecasting Air Quality
Day 2	**Activity 2-2:** Making a Simple Predictive Model for Ground-Level Ozone *Homework*: **Video 3-1**: Scientific Research and Air Quality and assign article for **Activity 3-1**: Scientific Literacy: Health Problems and Air Pollution
Day 3	**Activity 2-3**: Forecasting Air Quality **Activity 3-1**: Scientific Literacy: Health Problems and Air Pollution
Day 4	**Video 3-2**: Introduction to Solutions/Energy Choices Start **Activity 3-2**: Personal Choices at Home to Prevent Air Pollution
Day 5	Finish **Activity 3-2**: Personal Choices at Home to Prevent Air Pollution

WEEK 3	
Day 1	**Video 3-3**: Driving Choices and Air Pollution **Activity 3-3**: Driving Choices: Calculating Car Emissions
Day 2	Start **Activity 3-4:** The Clean Air Act
Day 3	Finish **Activity 3-4**: The Clean Air Act **Video 3-4**: North Carolina Clean Smokestacks Act
Day 4	Start **Activity 3-5:** Research and Action: Community Air Quality Project
Day 5	Finish **Activity 3-5**: Research and Action: Community Air Quality Project (Optional: If you want more time for the project, skip Activity 2-2.)

GROUPINGS BY TOPIC

1 day = 1 block period = approx. 90 minutes

These groupings focus on specific themes: ozone, particulate matter, North Carolina air quality, literacy, creativity and design, data analysis and modeling, meteorology, vehicles, choices at home, and policy issues. Most of these take from 3-4 days, using block periods. All of the groupings allow you to cover the desired air-quality topics in the most efficient way, making the most of valuable classroom time.

AIR QUALITY BASICS

THE ACTIVITY GUIDES FOR THIS GROUPING ARE INCLUDED IN THIS TEACHER GUIDE.

In this grouping, students learn the basics about air pollution and air quality, including sources of air pollution in the United States and North Carolina, how to read an Air Quality Index, seasonal patterns of ozone pollution and particulate matter, and ways to save energy – and prevent air pollution – through the choices we make at home.

AIR QUALITY BASICS	
Day 1	**Video 1-5:** Air Pollution in North Carolina **Activity 1-5:** Local Sources of Air Pollution
Day 2	**Activity 2-1**: What's an Air Quality Index? **Video 2-3**: Forecasting Air Quality
Day 3	**Video 3-2**: Introduction to Solutions/Energy Choices
Day 4	Finish **Activity 3-2**: Personal Choices at Home to Prevent Air Pollution

GROUND-LEVEL OZONE

Ground-level ozone is a significant air pollutant in North Carolina. Through a mix of hands-on, data-based, and creative activities, students will learn how ground-level ozone is formed and what kinds of health problems it can cause. They will make ozone indicators and hang them around campus. Along the way, they'll learn about the six criteria (or common) air pollutants (Video 1-4), the layers of the atmosphere, and the difference between ground-level ozone pollution (bad) and stratospheric ozone (good).

Before Day 1	*Homework*: Layers of the Atmosphere worksheet from **Activity 1-1:** What is Air?
Day 1	**Video 1-4:** The Criteria Pollutants Start **Activity 1-4:** The Criteria Pollutants and a Closer Look at Ozone
Day 2	Finish **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone Start **Activity 1-6**: Making and Using Ozone Indicators
Day 3	Finish **Activity 1-6:** Making and Using Ozone Indicators **Activity 2-2:** Making a Simple Predictive Model for Ground-Level Ozone
Day 4	**Video 3-1**: Scientific Research and Air Quality **Activity 3-1**: Scientific Literacy: Health Problems and Air Pollution

PARTICULATE MATTER

In addition to ground-level ozone pollution, particulate matter has been one of the two main pollutants of concern in North Carolina in recent years. This grouping introduces students to particulate matter, including its sources and health problems it can cause. Students will make particle collectors, set them out around campus, and examine them to see what they've found. They'll also learn about how the Air Quality Index is used to communicate about air pollution.

Day 1	**Video 1-5:** Air Pollution in North Carolina **Activity 1-5:** Local Sources of Air Pollution
Day 2	Do parts B and C of **Activity 2-1**: What's an Air Quality Index? **Video 2-3**: Forecasting Air Quality
Day 3	Start **Activity 1-7**: Sampling Particulate Matter (set out collectors) Start **Activity 3-1**: Scientific Literacy: Health Problems and Air Pollution (read articles related to particle pollution)
Day 4	Finish **Activity 1-7:** Sampling Particulate Matter Finish **Activity 3-1:** Scientific Literacy: Health Problems and Air Pollution **Video 3-1:** Scientific Research and Air Quality

NORTH CAROLINA AIR QUALITY FOCUS

Air pollution sources and air quality forecasting can vary from state to state. These activities and videos focus on air quality and air pollution in North Carolina, including sources of air pollution in the state and your local county, forecasting air quality in Charlotte, the different types of fuel used to generate electricity in the state, and North Carolina's Clean Smokestacks legislation. Students will use this knowledge as they explore choices they can make in their own lives to reduce air pollution (Activities 3-2 and 3-3).

Day 1	**Video 1-5:** Air Pollution in North Carolina **Activity 1-5:** Local Sources of Air Pollution
Day 2	**Video 2-3**: Forecasting Air Quality **Activity 2-3**: Forecasting Air Quality Start Parts A and B of **Activity 3-2**: Personal Choices at Home to Prevent Air Pollution
Day 3	Finish parts A and B of **Activity 3-2**: Personal Choices at Home to Prevent Air Pollution Start **Activity 3-3**: Driving Choices: Calculating Car Emissions
Day 4	Finish **Activity 3-3:** Driving Choices: Calculating Car Emissions **Video 3-4:** North Carolina Clean Smokestacks Act

VEHICLES: PROBLEMS AND SOLUTIONS

This grouping builds on the passion many students have for cars. Students will learn why vehicle exhaust is a major source of air pollution in North Carolina and what choices they can make to help reduce air pollution. They'll learn about federal car emission standards as well as how to calculate the air pollution emissions created at the electric power plant when charging an all-electric car.

Day 1	**Video 1-2**: Combustion **Activity 1-2**: Combustion Equations Do part 2 of **Activity 1-7**: Sampling Particulate Matter
Day 2	**Video 1-4:** **Activity 2-2**: Making a Simple Predictive Mode for Ground-Level Ozone
Day 3	**Video 1-5**: Air Pollution in North Carolina **Activity 1-5**: Local Sources of Air Pollution
Day 4	**Video 3-3**: Driving Choices and Air Pollution **Activity 3-3**: Driving Choices: Calculating Car Emissions

CHOICES AT HOME

This grouping makes it personal. Students will learn how their activities at home rely on energy and how that energy use contributes to air pollution. They'll calculate air pollution emissions for various energy uses and learn about some of the choices they can make to reduce that air pollution.

Day 1	**Video 1-2**: Combustion **Activity 1-2**: Combustion Equations **Start Activity 1-5**: Local Sources of Air Pollution
Day 2	Finish **Activity 1-5**: Local Sources of Air Pollution
Day 3	**Video 3-2**: Introduction to Solutions/Energy Choices **Activity 3-2**: Personal Choices at Home to Prevent Air Pollution

METEOROLOGY

Meteorology forms the foundation for understanding many aspects of air pollution, air quality, and air quality forecasting. To deepen your students' understanding of air quality, try having them keep a weather log for one week prior to teaching this grouping (See itsourair.org/weatherlog for information on how to do a weather log). Students can spend a few minutes of class each day recording data such as temperature, relative humidity, wind speed and direction, precipitation, cloud cover, and the Air Quality Index (forecast and previous). Building on that knowledge, these activities will reinforce meteorology content while teaching about air quality. After reviewing the basic properties of air in Activity1-1, students will analyze data and maps in Activities 2-1 and 2-3.

Day 1	**Video 1-1**: (Parts 1 & 2): What is Air? **Activity 1-1**: What is Air?
Day 2	**Activity 2-1**: What's an Air Quality Index?
Day 3	**Activity 2-3**: Forecasting Air Quality **Video 2-3**: Forecasting Air Quality

INTRO TO CHEMISTRY

These three activities emphasize fundamental concepts in chemistry, including molecular formulas; simple chemical equations; and the interactions among pressure, temperature, and volume.

Day 1	**Video 1-1**: (Parts 1 & 2): What is Air? **Activity 1-1**: What is Air?
Day 2	**Video 1-2**: Combustion **Activity 1-2**: Combustion Equations
Day 3	**Activity 1-6**: Making and Using Ozone Indicators

DATA ANALYSIS & MODELING

In this grouping, students will get a chance to try their hand at data analysis and modeling. They'll use data to identify seasonal patterns of air pollution, create a simple predictive model for ozone, and (utilizing given maps and data) make an air-quality forecast for Charlotte, NC. Data analysis and modeling is how we know what we know about the world, so these activities are a marvelous opportunity for students to understand the scientific process at a deeper level. These skills are required for many careers related to the environment, meteorology, and science in general.

Day 1	**Activity 2-1**: What's an Air Quality Index?
Day 2	**Activity 2-2**: Making a Simple Predictive Model for Ground-Level Ozone
Day 3	**Activity 2-3**: Forecasting Air Quality **Video 2-3**: Forecasting Air Quality

CREATIVITY AND DESIGN FOCUS

These activities may appeal to students who have an artistic inclination or are visual learners. In Activity 1-4, students will create comic books. In part C of Driving Choices (Activity 3-3), they will come up with a slogan or logo and create a bumper sticker. Some of these activities could be vertically aligned with career/tech courses, such as graphic design, drafting, or art.

Day 1	Start **Activity 3-4:** The Clean Air Act (have students make poster or design campaign instead of writing paper)
Day 2	Finish **Activity 3-4:** The Clean Air Act (have students make poster or design campaign instead of writing paper) Start **Activity 1-4:** The Criteria Pollutants and a Closer Look at Ozone
Day 3	Work on **Activity 1-4**: The Criteria Pollutants and a Closer Look at Ozone
Day 4	Finish **Activity 1-4:** The Criteria Pollutants and a Closer Look at Ozone **Video 3-3:** Driving Choices and Air Pollution Do part C of **Activity 3-3:** Driving Choices: Calculating Car Emissions

POLICY

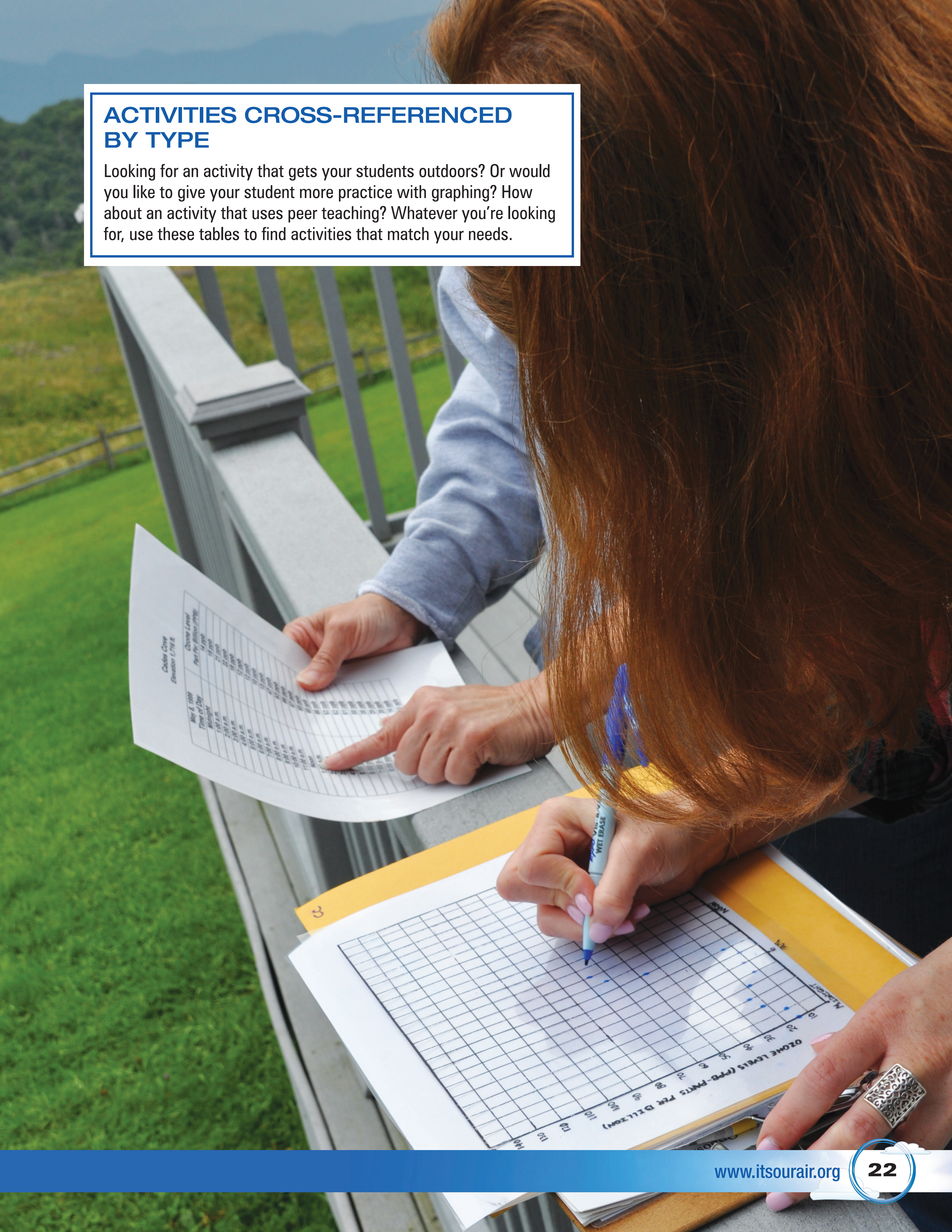
This grouping is geared toward AP Environmental Science students to help them prepare for the policy content they'll need to know for AP exam. It focuses on the Clean Air Act, EPA criteria pollutants and their sources, and federal car emission standards.

Day 1	**Video 1-4**: The Criteria Pollutants Start **Activity 3-4**: The Clean Air Act
Day 2	Start **Activity 3-4**: The Clean Air Act **Video 3-4**: North Carolina Clean Smokestacks Act
Day 3	**Video 3-1**: Scientific Research and Air Quality **Video 1-5**: Air Pollution in North Carolina **Activity 1-5**: Local Sources of Air Pollution
Day 4	Do parts B and C of **Activity 2-1**: What's an Air Quality Index? Do parts A and B of **Activity 3-3**: Driving Choices: Calculating Car Emissions

LITERACY FOCUS

This grouping may appeal to English teachers or science teachers who want to emphasize reading and writing while exposing students to scientific topics. The activities here allow students to learn through writing about air pollution, health problems caused by air pollution, and air quality legislation. They'll also have a chance to read and evaluate some articles about science and one or more scientific papers published in peer-reviewed journals. Students can practice the scientific literacy skill of making and interpreting graphs with these activities as well. Knowing how to read and write about scientific topics is an important skill for many careers.

Day 1	**Video 1-5:** Air Pollution in North Carolina **Activity 1-5:** Local Sources of Air Pollution
Day 2	**Video 3-1:** Scientific Research and Air Quality **Activity 3-1:** Scientific Literacy: Health Problems and Air Pollution
Day 3	Start **Activity 3-4**: The Clean Air Act
Day 4	Finish **Activity 3-4:** The Clean Air Act **Video 3-4:** North Carolina Clean Smokestacks Act



ACTIVITIES CROSS-REFERENCED BY TYPE

Looking for an activity that gets your students outdoors? Or would you like to give your student more practice with graphing? How about an activity that uses peer teaching? Whatever you're looking for, use these tables to find activities that match your needs.

IT'S OUR AIR ACTIVITIES CROSS-REFERENCED BY TYPE

Activity/Video	Chemical Equations	Community Project	Creative Writing	Critical Media Analysis	Critical Thinking	Data Collection	Data Analysis	Demo	Drawing	Flipped Classroom	Formative Assessment	Graphing	Graph Analysis	Internet	Model Development	Microscope
MODULE 1																
Activity 1-1 What Is Air?	X					X	X	X		X	X	X				
Video 1-1 What Is Air?	X							X		X						
Activity 1-2 Combustion Equations								X		X						
Video 1-2 Combustion								X		X						
Activity 1-3 Parts Per Million								X								
Activity 1-4 A Closer Look at Ozone			X						X	X						
Video 1-4 Criteria Pollutants										X						
Activity 1-5 Local Sources of Air Pollution							X			X		X	X			
Video 1-5 Air Pollution in North Carolina										X						
Activity 1-6 Making & Using Ozone Indicators					X	X	X									
Activity 1-7 Sampling Particulate Matter						X	X									X

Activity/Video	Type							Scope					Learning Style			Location	
	Peer Teaching	Performance Task	Presentation	Scientific Literacy	Station Work	Stewardship	Volume Conversion	General	US	NC	Local	School	Hands On	Visual	Auditory	Classroom	Outdoors
MODULE 1																	
Activity 1-1 What Is Air?					X		X	X					X	X		X	
Video 1-1 What Is Air?								X						X		X	
Activity 1-2 Combustion Equations								X					X	X		X	
Video 1-2 Combustion								X						X		X	
Activity 1-3 Parts Per Million	X						X	X					X	X		X	
Activity 1-4 A Closer Look at Ozone	X		X					X						X		X	
Video 1-4 Criteria Pollutants									X					X		X	
Activity 1-5 Local Sources of Air Pollution	X		X						X	X				X	X	X	
Video 1-5 Air Pollution in North Carolina										X	X			X	X	X	
Activity 1-6 Making & Using Ozone Indicators												X	X	X			X
Activity 1-7 Sampling Particulate Matter												X	X	X			X

	Type															
Activity/Video	**Chemical Equations**	**Community Project**	**Creative Writing**	**Critical Media Analysis**	**Critical Thinking**	**Data Collection**	**Data Analysis**	**Demo**	**Drawing**	**Flipped Classroom**	**Formative Assessment**	**Graphing**	**Graph Analysis**	**Internet**	**Model Development**	**Microscope**
MODULE 2																
Activity 2-1 What's an Air Quality Index?					X	X	X							X		
Activity 2-2 Making a Simple Predictive Model for Ground-Level Ozone					X		X					X	X		X	
Activity 2-3 Forecasting Air Quality					X		X			X					X	
Video 2-3 Forecasting Air Quality										X						
MODULE 3																
Activity 3-1 Scientific Literacy: Health Problems and Air Pollution					X					X						
Video 3-1 Scientific Research and Air Quality					X					X						
Activity 3-2 Personal Choices at Home to Prevent Air Pollution					X		X			X						
Video 3-2 Home Energy Choices					X		X			X						
Activity 3-3 Calculating Car Emissions										X				X		
Video 3-3 Driving Choices & Air Pollution										X						
Activity 3-4 The Clean Air Act				X						X				X		
Video 3-4 North Carolina Clean Smokestacks										X						
Activity 3-5 Research & Action: Community Air Quality Project																

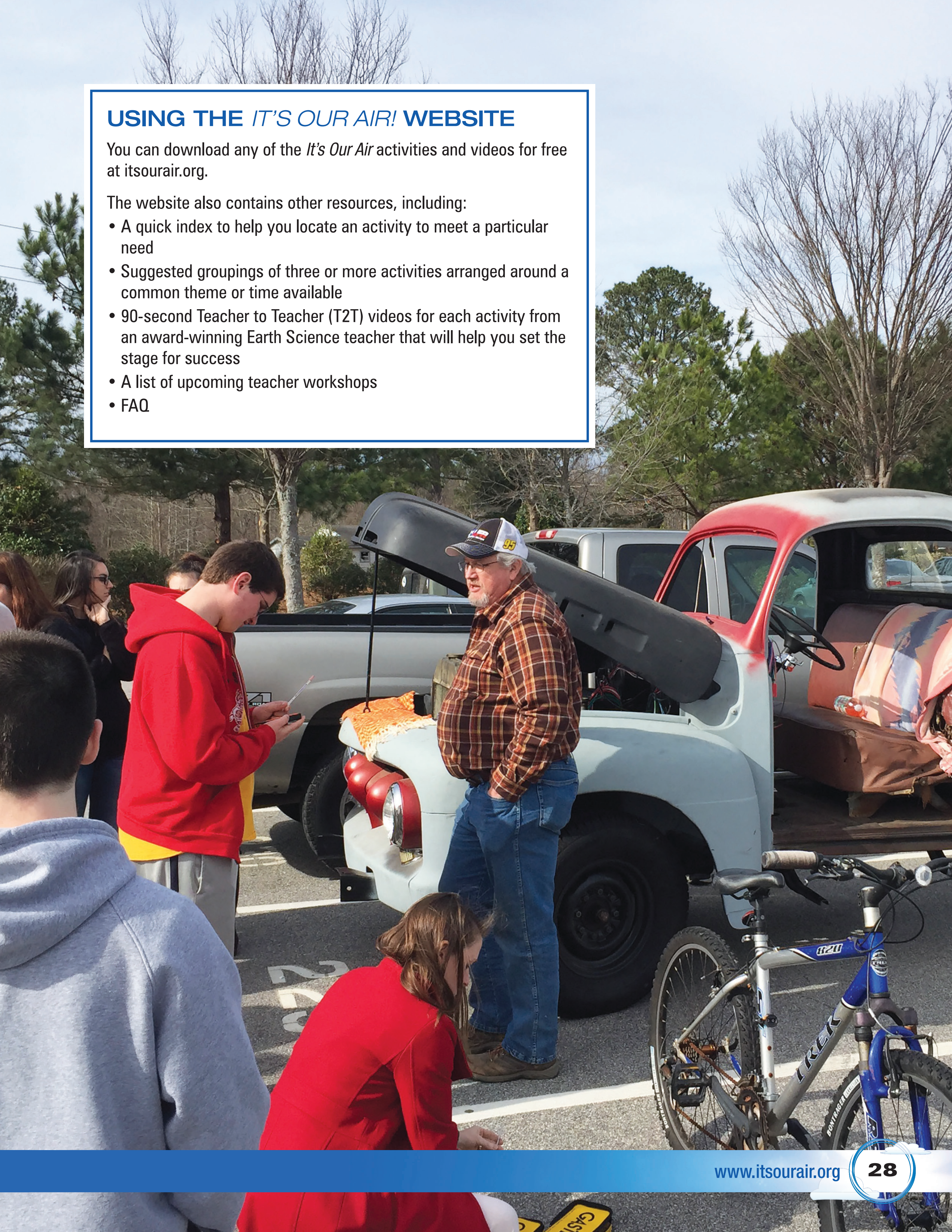
	Type							Scope					Learning Style			Location	
Activity/Video	Peer Teaching	Performance Task	Presentation	Scientific Literacy	Station Work	Stewardship	Volume Conversion	General	US	NC	Local	School	Hands On	Visual	Auditory	Classroom	Outdoors
MODULE 2																	
Activity 2-1 What's an Air Quality Index?									X	X	X			X		X	
Activity 2-2 Making a Simple Predictive Model for Ground-Level Ozone								X		X				X		X	
Activity 2-3 Forecasting Air Quality	X		X							X				X		X	
Video 2-3 Forecasting Air Quality										X				X		X	
MODULE 3																	
Activity 3-1 Scientific Literacy: Health Problems and Air Pollution	X			X				X	X					X		X	
Video 3-1 Scientific Research and Air Quality								X	X					X		X	
Activity 3-2 Personal Choices at Home to Prevent Air Pollution								X						X		X	
Video 3-2 Home Energy Choices								X						X		X	
Activity 3-3 Calculating Car Emissions								X						X		X	
Video 3-3 Driving Choices & Air Pollution								X						X		X	
Activity 3-4 The Clean Air Act		X							X					X	X	X	
Video 3-4 North Carolina Clean Smokestacks										X				X		X	
Activity 3-5 Research & Action: Community Air Quality Project		X	X			X		X					X			X	X

USING THE *IT'S OUR AIR!* WEBSITE

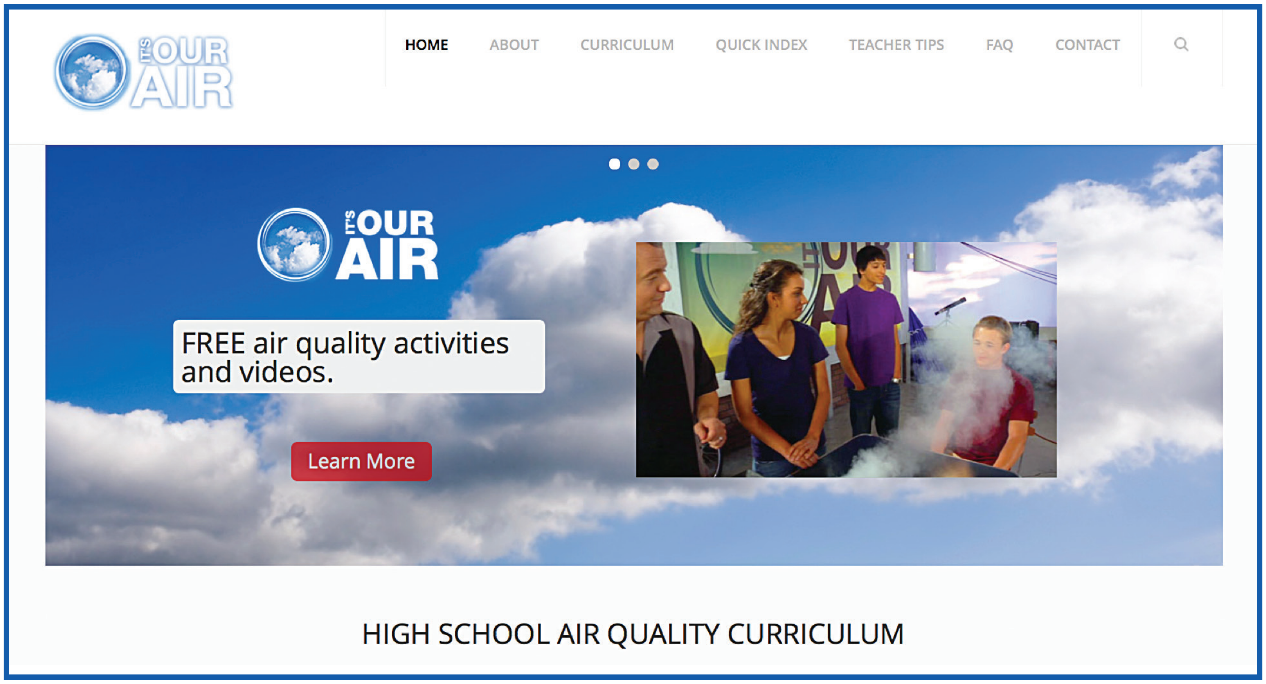
You can download any of the *It's Our Air* activities and videos for free at itsourair.org.

The website also contains other resources, including:

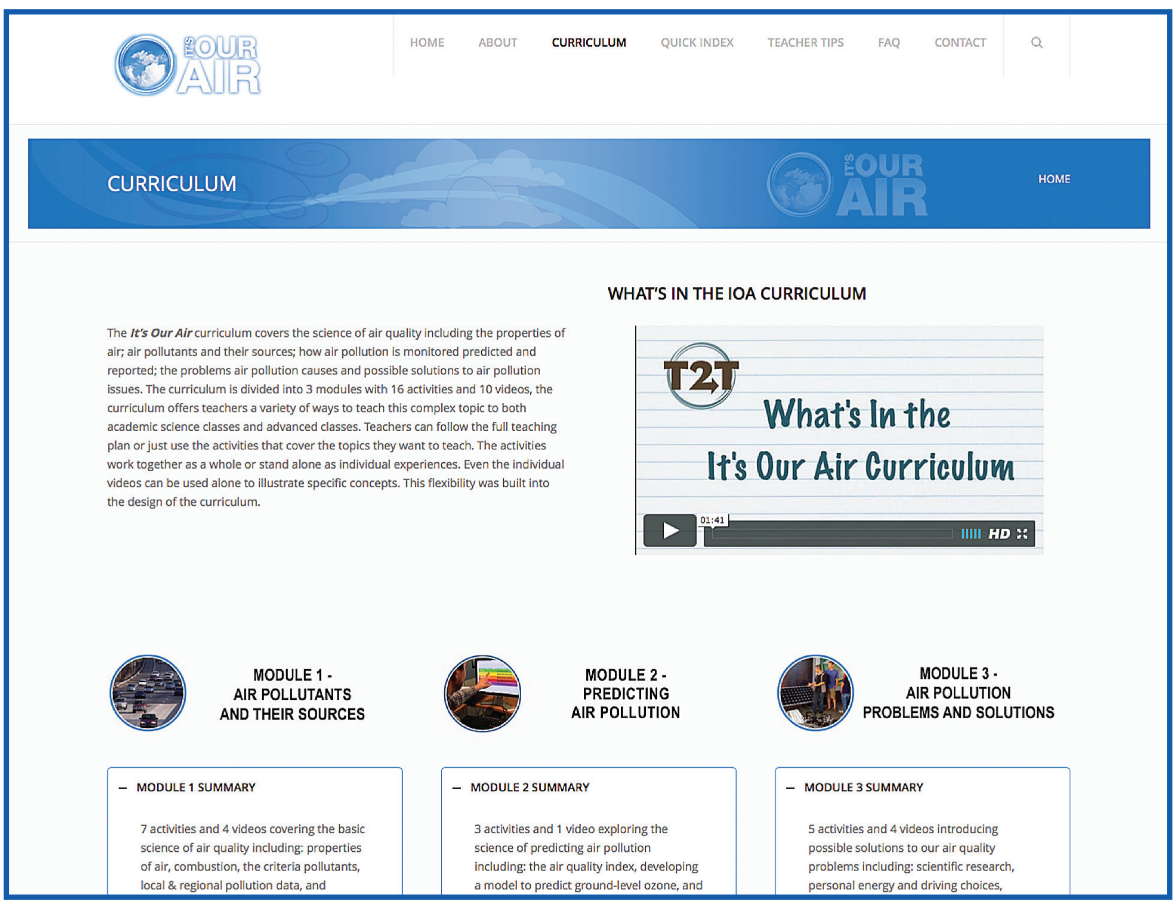
- A quick index to help you locate an activity to meet a particular need
- Suggested groupings of three or more activities arranged around a common theme or time available
- 90-second Teacher to Teacher (T2T) videos for each activity from an award-winning Earth Science teacher that will help you set the stage for success
- A list of upcoming teacher workshops
- FAQ



Here's a quick overview of the website. Tabs at the top of every page allow you to quickly jump to where you want to go.



The Curriculum page shows you all the activities and videos for each of the three modules. Click on any activity to read a summary.



Then click on “more info” to see the page for that activity, which has critical information such as time needed, materials, and essential standards. This is where you can download the activity and view or download the video. You’ll also find a short Teacher to Teacher (T2T) video that gives you inside information to minimize planning and set-up time and maximize your success.

1-2 COMBUSTION & COMBUSTION EQUATIONS

HOME

DOWNLOAD ACTIVITY GUIDE

DOWNLOAD VIDEO FILE

COMBUSTION EQUATIONS ACTIVITY

In the hands-on activity, students use molecular model sets to become familiar with some simple chemical equations describing combustion, and to see how the burning of fossil fuels produces carbon dioxide.

ESSENTIAL QUESTIONS:
What is combustion?
What molecules does combustion produce?
What are some of the benefits of combustion for humans?

TIME NEEDED: 45 minutes

– MATERIALS:

Video: Combustion (included)
Molecule sets
Worksheet (included))

TOPICS: combustion, combustion equations, conservation of mass, combustion’s relationship to air pollution, our dependence on combustion.

TYPES: hands-on demonstration, video

ESSENTIAL STANDARDS for Earth/Environmental Science:
EEn.2.5.1. Summarize the structure and composition of our atmosphere
EEn.2.5.5 Explain how human activities affect air

COMBUSTION VIDEO

A video introduces to the concept of combustion as a chemical reaction and illustrates how combustion causes the rearrangement of atoms from one set of molecules to another set of molecules, and how air pollution can result when other gases in our atmosphere and other substances in fuel are added into the combustion mix.

Video downloads are able to display subtitles. We recommend using VLC media player for optimal playback of subtitles.

T2T Teacher To Teacher

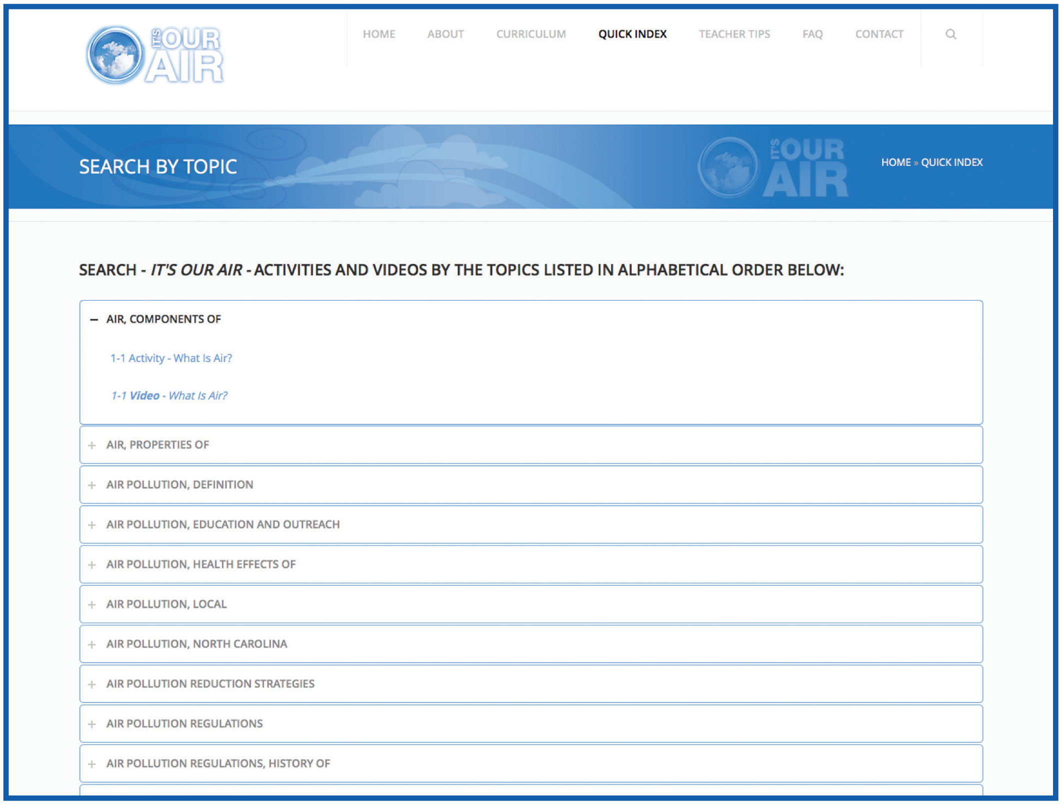
COMBUSTION & COMBUSTION EQUATIONS - TEACHER TO TEACHER TIPS

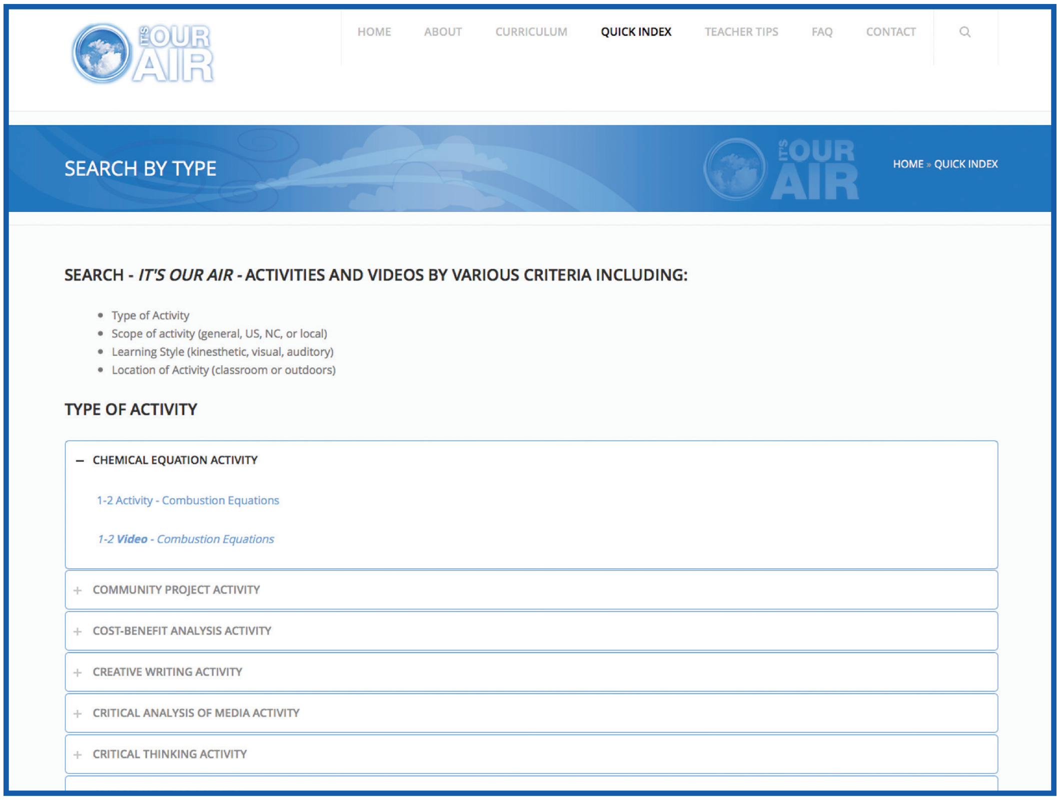
The quick video below has tips for doing this activity from Mark Townley, an award-winning, North Carolina high school teacher. Mark helped develop ***It’s Our Air*** and has used each of these activities with his students.

T2T Activity 1-2 Combustion Equations

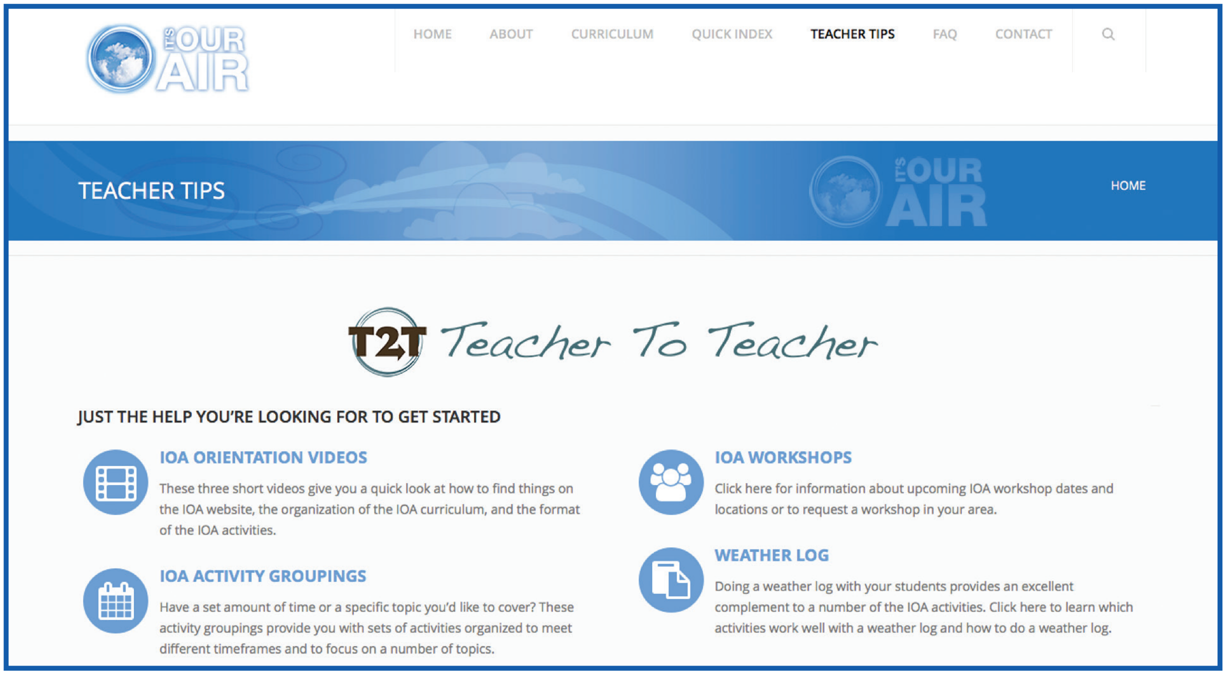
BACK TO CURRICULUM PAGE

The Quick Index tab lets you search for activities by topic, type, essential standards, and videos. This is helpful if you're looking for an activity to meet a particular need, such as an activity about forecast models or an activity that involves peer teaching.

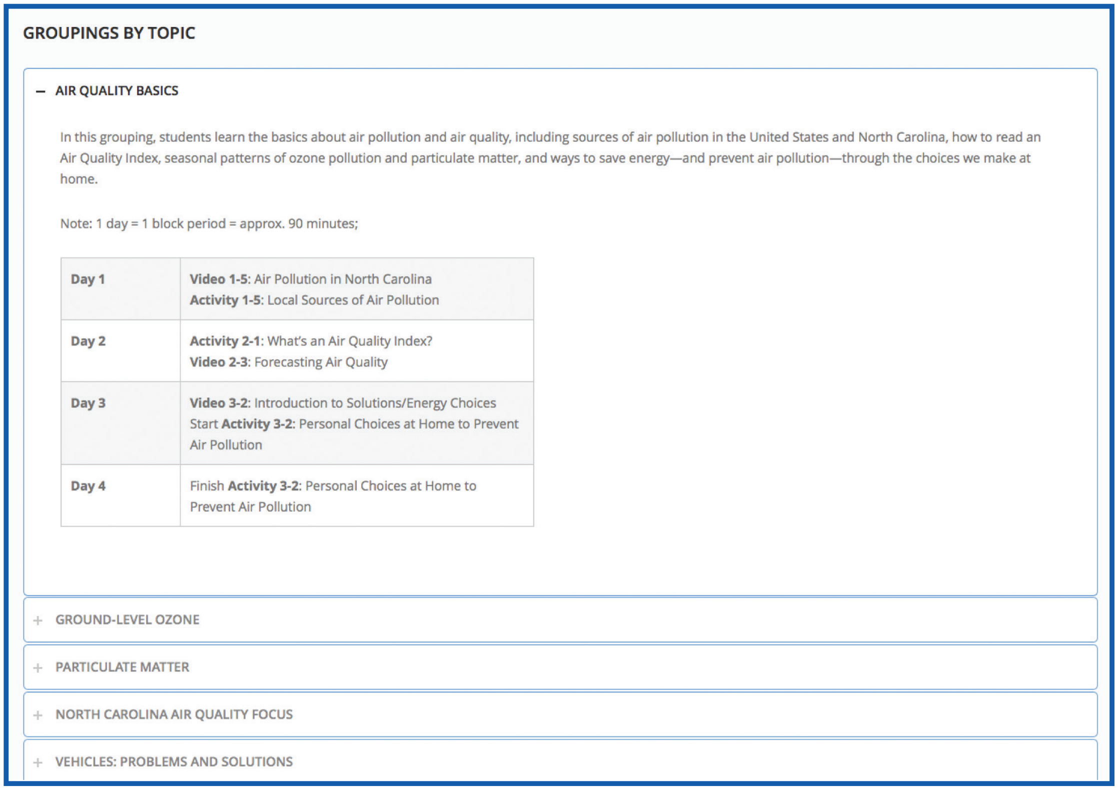




The Teacher Tips tab takes you to our Teacher To Teacher (T2T) resources designed to give you a head start on your planning: orientation videos, listings of upcoming teacher workshops, activity groupings, and weather log instructions.



The IOA Activity Groupings are particularly useful. We've created time-based groupings for one week, two weeks or three weeks and topic-based groupings that contain activities that focus on particular topics, such as ozone pollution.


GROUPINGS BY TOPIC

– AIR QUALITY BASICS

In this grouping, students learn the basics about air pollution and air quality, including sources of air pollution in the United States and North Carolina, how to read an Air Quality Index, seasonal patterns of ozone pollution and particulate matter, and ways to save energy—and prevent air pollution—through the choices we make at home.

Note: 1 day = 1 block period = approx. 90 minutes;

Day 1	**Video 1-5**: Air Pollution in North Carolina **Activity 1-5**: Local Sources of Air Pollution
Day 2	**Activity 2-1**: What's an Air Quality Index? **Video 2-3**: Forecasting Air Quality
Day 3	**Video 3-2**: Introduction to Solutions/Energy Choices Start **Activity 3-2**: Personal Choices at Home to Prevent Air Pollution
Day 4	Finish **Activity 3-2**: Personal Choices at Home to Prevent Air Pollution

+ GROUND-LEVEL OZONE

+ PARTICULATE MATTER

+ NORTH CAROLINA AIR QUALITY FOCUS

+ VEHICLES: PROBLEMS AND SOLUTIONS

THREE SAMPLE ACTIVITIES

To give you a taste of It's Our Air, we've included three of the activities here.

1-5: Local Sources of Air Pollution
2-1: What's an Air Quality Index?
3-2: Personal Choices at Home to Prevent Air Pollutions

These three activities are the ones needed to do the Air Quality Basics Grouping. Taken together, these three activites give a good overview of air pollution and air quality in North Carolina. In Activity 1-5, students research and graph the sources of air pollution in the United States, North Carolina and their own county. In Activity 2-1, students learn how to read an Air Quality Index and discover seasonal patterns of ozone pollution and particulate matter. In Actitiy 3-2, they will learn ways to save energy – and prevent air pollution – through the choices they make at home.

AIR QUALITY BASICS GROUPING

AIR QUALITY BASICS	
Day 1	**Video 1-5:** Air Pollution in North Carolina **Activity 1-5:** Local Sources of Air Pollution
Day 2	**Activity 2-1**: What's an Air Quality Index? **Video 2-3**: Forecasting Air Quality
Day 3	**Video 3-2**: Introduction to Solutions/Energy Choices
Day 4	Finish **Activity 3-2**: Personal Choices at Home to Prevent Air Pollution

Module 1: Activity 5

Local Sources of Air Pollution

IT'S OUR AIR

SUMMARY

Students will learn the sources of some common air pollutants by making pie charts showing the main sources of PM2.5, PM10, nitrogen dioxide (or nitrogen oxides) and sulfur dioxide for the United States as a whole, their state, and their county. They will generate explanations for the similarities and differences among the sources for different geographic areas.

ESSENTIAL QUESTIONS

- Where do air pollutants come from?
- What can we learn by comparing local sources of air pollution to national sources of air pollution?

TIME NEEDED

This activity, including the warm up and wrap up, should take about 90 minutes.

2012 North Carolina ESSENTIAL STANDARDS FOR EARTH/ENVIRONMENTAL SCIENCE

- 2.5.5 Explain how human activities affect air quality.
- 2.8.2. Critique conventional and sustainable agriculture and aquaculture practices in terms of their environmental impacts.

MAKING CONNECTIONS

This activity is yet another example of how displaying data graphically can yield insights that might elude us if data is presented as columns and rows of numbers. Making pie charts allows students to see what proportion of emissions of various air pollutants come from different sources. The pie charts will also make it easier to compare and contrast sources from the United States, North Carolina, and a particular county.

Synthesizing different types of information to draw conclusions is an essential scientific skill. In this activity students will research their state and county in order to generate explanations for the similarities and differences among the charts.

BACKGROUND

In this activity, students will be focusing on discovering the major sources of emissions of particulate matter, nitrogen dioxide, and sulfur dioxide in the United States, their state, and their county. Students will learn more about the problems caused by these pollutants, as well as about monitoring and setting limits on pollutants, in later activities in this curriculum.

There will be some interesting similarities and differences when comparing pollution sources for the United States as a whole with your county. For example, if your county doesn't have a power plant that burns fossil fuel, electric generation will not be the largest source of sulfur dioxide for your county, although it certainly is for the United States as a whole. The graphs for nitrogen dioxide might look more similar, since cars are the largest source and most counties have plenty of cars. As another example, in rural counties, agriculture might be the largest source of PM10, while for the United States as a whole, dust from roads and construction is the largest source of PM10.

PRIMARY AND SECONDARY POLLUTANTS

A primary pollutant is emitted directly from a smokestack, exhaust pipe, chemical vat, or other specific source that can be pointed to. Secondary pollutants, also called area pollutants, are formed when primary pollutants change in the air. Sulfur dioxide (SO2) is a great example. It is emitted from a coal smokestack as a primary pollutant. Once in the air, it can react with water to form a secondary pollutant called sulfuric acid (one type of acid rain):

$$SO_2 + 2H_2O = 2H_2SO_4$$

THE SIX CRITERIA POLLUTANTS

EPA sets the standards for six criteria pollutants: ground-level ozone, particle pollution (also called particulate matter), nitrogen dioxide, carbon monoxide, sulfur dioxide, and lead. Nationally, the levels of all of these pollutants have fallen significantly since 1980, despite the fact that the population, gross domestic product, energy use, and vehicle miles traveled have all risen. However, in many urban areas ozone and particulate matter still pose a challenge.

Nitrogen dioxide (NO_2) is a kind of nitrogen oxide (NO_x), a class that also includes nitric oxide (NO). NO_x are formed during combustion in air at very high temperatures (typically 2700°F or higher), such as in a car engine or a boiler at a power plant. NO_x react with other molecules in the air to produce ground-level ozone, ammonia, nitric acid and acid rain. The largest sources of NO_x include cars and other vehicles with internal combustion engines, electrical generation, and industry.

Ground-level ozone is a secondary pollutant that forms when nitrogen oxides (NO_x) and volatile organic compounds (VOCs) react in the presence of sunlight and warm temperatures (usually over 75° F). NO_x comes from burning fuels. VOCs are chemicals containing carbon that evaporate easily – which usually means they are smelly. Sources of VOCs include cleaning chemicals, solvents, paints, unburned gasoline, hog waste lagoons, and natural sources such as trees. In North Carolina, almost all VOCs are from natural sources. Ozone is most likely to form on a hot summer afternoon near cars and in cities.

Particulate matter refers to a size rather than a chemical composition. Particulate matter can be either solid particles (such as dust) or tiny liquid droplets. For example, sulfur dioxide and nitrogen oxides can react with other chemicals in the air to form tiny droplets. Particulate matter is divided into two categories. PM10, or "coarse" particles, refers to particles less than 10 micrometers in diameter. PM2.5, or "fine" particles, refers to particles smaller than 2.5 micrometers. For comparison, fine beach sand is about 90 micrometers in diameter, and a human hair is between 50 and 70 micrometers in diameter. Reactions in the atmosphere among naturally occurring and manmade chemicals (such as sulfur dioxide and nitrogen oxides) are a major source of particulate matter. Other sources of particulate matter include construction sites, unpaved roads, fields, forest fires, and smokestacks.

Carbon monoxide (CO) is a product of incomplete combustion. When inhaled, it reduces oxygen delivery in the body. By far vehicles (cars, trucks, construction equipment) contribute the most carbon monoxide in the atmosphere.

Sulfur dioxide (SO_2) is a kind of sulfur oxide (SO_x). The largest source of sulfur dioxide is fuel combustion during generation of electricity, but it can be generated any time sulfur-rich fossil fuels such as coal are burned. Sulfur dioxide causes health problems, contributes to acid rain, and contributes to particle pollution.

Lead in the atmosphere has fallen the most dramatically of the six criteria pollutants, primarily due to the phase-out of leaded gasoline.

MATERIALS

- Internet connection or hard copy of data
- For each group: (3) 8.4" x 11" sheets of paper, (1) poster board, and markers

WARM**UP**

Have your students review the Criteria Pollutants Reference Sheet they used while watching the video about the six criteria pollutants as part of Activity 2 (The Criteria Pollutants and a Closer Look at Ozone). As a class, discuss the six criteria pollutants, focusing on how they are formed.

Show your students the video to give them an introduction to the most prevalent air pollution issues in North Carolina. This information gives a larger context for this activity and sets the stage for future activities.

Divide the class into 6 groups, and assign each group a criteria pollutant to research. If you have a large class and your groups have more than 4 students each, you may want to split particulate matter into two groups: one for 2.5 and one for 10 micrometer PM. If you need to have 8 groups, you can have one group do a multi-pollutant comparison (on the bottom left of the main emissions page.) The multi-pollutants are already in percent, so they just have to copy the graphs onto the poster. With groups of 4, three students can draw the pie charts while the fourth does the calculations.

AIR POLLUTION IN NORTH CAROLINA **VIDEO**

IN THIS VIDEO, STUDENTS:

- Are introduced to the major pollution issues in North Carolina including ground-level ozone, particle pollution, acid deposition, mercury deposition, and nitrogen deposition;
- Visit the North Carolina mountains, piedmont and coastal plain to learn about air pollution issues these regions and the sources of the air pollution..
- Hear from the NC Division of Air Quality Director, park rangers, a biomedical researcher, a county air quality official, a riverkeeper, and an air quality expert.

Video Length: 10-20 minutes

Key elements: video footage and interviews.

Teacher Tips

Set-up Time: 5 Mins.

Activity Time: 90-120 Mins.

- I place my students in groups of three and assign one student the U.S. perspective, one the county perspective, and one the North Carolina perspective. They each make their own pie charts and then I have them brainstorm all of their comparisons on a sheet of paper that they turn in with the one-page paper. That way the student that writes the paper has the information they need from the group to make their job more efficient and the grades can be as individualized as possible.
- To save time, have the students use symbols instead of solid colors for the pie charts.
- Lead may not occur in enough quantity at the county level to show any numbers for the x-axis of the chart resulting in all zeros for the county graph (less than a short ton for all of the pollution.) I have students put tenths of a point on their charts and made one part of the pie 99.5%, another 0.3%, and the third 0.2%.

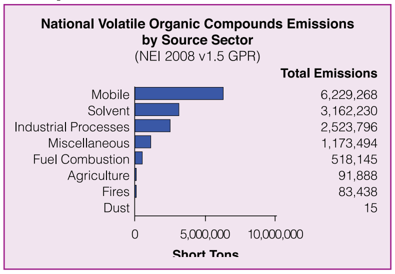
-Mark Townley

THE ACTIVITY

1. FIND TOTAL EMISSIONS

- Use the internet (or use information given to your by your teacher) to find data about the main sources of emissions of your assigned pollutant: http://www.epa.gov/air/emissions/index.htm

Example of Total Emission Chart



2. CALCULATE PERCENTAGES

- If the information is not already given as percentages, convert it into percentages by adding up the total emissions, then dividing the emissions from each category by the total emissions, and multiplying by 100.

Example of Calculated Percentage

Total Emissions = 13,782,274
Mobile = 6,229,268
Mobile ÷ Total x 100 = 45%

3. CREATE PIE CHART

- On three 8/5" x 11" sheets of paper, make three pie charts showing the percentages of the emissions that come from each source for the United States, North Carolina and your county. Multiply 360 by the decimal form of each percentage to figure out how many degrees on your protractor you should use to represent each source. For example, if fires account for 3% of the total PM 2.5 emissions, multiply 360 by 0.03 and you'll see that the "fire" slice of the pie should be 10.8 degrees (round up to 11). If there are a number of sources that each account for 2% or less of the total, you may want to lump these into one category called "other sources."
- Make sure to label each pie chart "Sources of __________ in the United States," "Sources of ________ in North Carolina," or "Sources of __________ in _________County." Place the three pie charts on a poster board.
- Include a legend explaining identifying each category, and listing some specific sources in that category. (You can click on the source categories under each bar graph on the EPA website given above to find out specific sources. Example: Dust – unpaved roads, paved roads, construction.) Include illustrations if you like.

4. DISCUSS FINDINGS

- In your group, discuss the differences and similarities among the pie charts for the United States, North Carolina, and your county. Come up with several reasons to explain the similarities and differences.

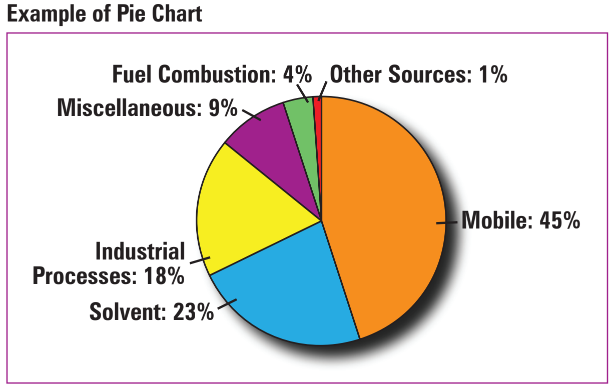
5. WRITE 1-PAGE SUMMARY

- As a group, write a one-page paper comparing and contrasting your three pie charts. If the same category accounts for the largest share of emissions in each pie chart, explain why, using your knowledge of how the pollutant is produced. If there are significant differences among the charts, explain those as well.

6. SHARE FINDINGS

- Choose a representative from your group to share your finding with the class discussing the similarities and differences in the sources for your assigned pollutant in the United States, your state, and your county and possible reasons for those similarities and differences.

Example of Pie Chart



WRAP UP AND ACTION

Display the posters and discuss them as a class. Have representatives from each group discuss the similarities and differences in the sources for their assigned pollutant in the United States, your state, and your county and possible reasons for those similarities and differences. You may wish to display the posters in the school library or other public space.

In a class discussion, ask students how their daily activities influence the emission of the four pollutants depicted in the pie charts.

ASSESSMENT

HAVE STUDENTS:

Explain in writing the main sources for nitrogen dioxide, sulfur dioxide, PM2.5 and PM10, and explain, for each of those four pollutants, the reasons behind the similarities and/or differences in the national sources vs. local sources.

EXTENSIONS

If you and your students are interested in finding out how much and what kind of pollution is emitted by specific businesses, industries, or institutions in your county, you can investigate on www.scorecard.org or this website hosted by the North Carolina Division of Air Quality:
https://xapps.ncdenr.org/aq/ToxicsReport/toxrpt.jsp?ibeam=true

Here are some directions for the scorecard website:

- From the home page, enter your zip code.
- Under "Air," click on "Get a list of the top polluters"
- Select a pollutant (where it says "select your ranking criteria")

RESOURCES

A good source of information about sources of emissions for a variety of pollutants for the entire US, any state, and any county is on the EPA website. Emissions are given in tons.

http://www.epa.gov/air/emissions

For more information on any of the criteria pollutants, see "Basic Information" on the EPA Air Trends website. Choose a pollutant from the list on the left side of the webpage.

http://www.epa.gov/airtrends/sixpoll.html

This page on the Division of Air Quality website lists air pollution by facility in each county for a wide variety of pollutants:

https://xapps.ncdenr.org/aq/ToxicsReport/toxrpt.jsp?ibeam=true

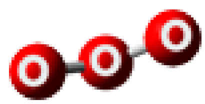
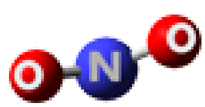
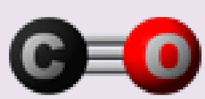
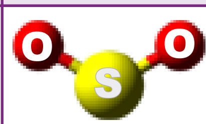
To view the measured concentrations of air pollutants in your county, visit this website of the NC Division of Air Quality: http://www.ncair.org/monitor/data/

IT'S OUR AIR

Local Sources of Air Pollution

Student Page #1

CRITERIA POLLUTANTS
REFERENCE SHEET

NAME	SYMBOL	MOLECULE	SOURCES	PROBLEMS CAUSED
Ozone	O_3		Combustion, VOC's + NO2 + sunlight + heat, vehicles, power plants, lightning	Breathing problems for people with lung diseases such as asthma, children, older adults, and people who are active outdoors. Premature death from heart or lung disease.
Particle Pollution or Particulate Matter	PM10 PM2.5	NA	**COARSE PARTICLES**: <10 micrometers – dust storms, mining. **FINE PARTICLES**: <2.5 micrometers – chemical processes, combustion, factories, power plants, vehicles	When inhaled can cause serious health problems and premature death. In air can cause visual haze.
Nitrogen Dioxide	NO_2 (NO_X)		Combustion, vehicles, power plants	Makes asthma worse and increases respiratory illnesses. Contributes to ground-level ozone, acid rain, nutrient over-loading in streams and lakes.
Carbon Monoxide	CO		Vehicles, industrial processes, residential wood burning, forest fires	At low levels-harmful to people with heart conditions. At high levels-poisionous, can kill you.
Sulfur Dioxide	SO_2		Burning coal or oil that contains sulfur	Breathing problems. Contributes to acid rain and particle pollution.
Lead	Pb		Historically – vehicles Currently – lead smelters	Inhaling lead is harmful to brain function in children and cardiovascular disease in adults.

Local Sources of Air Pollution

Student Page #2

THE ACTIVITY

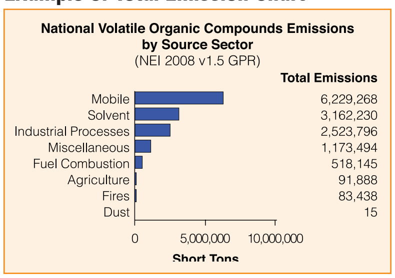
Assigned Pollutant: ____________________

You will make three posters showing the sources of your assigned pollutant in (1) the United States, (2) North Carolina, and (3) your county.

1. FIND TOTAL EMISSIONS

- Use the internet (or use information given to your by your teacher) to find data about the main sources of emissions of your assigned pollutant: http://www.epa.gov/air/emissions/index.htm

Example of Total Emission Chart



2. CALCULATE PERCENTAGES

- If the information is not already given as percentages, convert it into percentages by adding up the total emissions, then dividing the emissions from each category by the total emissions, and multiplying by 100.

Example of Calculated Percentage

Total Emissions=13,782,274
Mobile=6,229,268
Mobile ÷ Total x 100 = 45%

3. CREATE PIE CHART

- Make a pie chart poster showing the percentages of the emissions that come from each source. Multiply 360 by the decimal form of each percentage to figure out how many degrees on your protractor you should use to represent each source. For example, if fires account for 3% of the total PM 2.5 emissions, multiply 360 by 0.03 and you'll see that the "fire" slice of the pie should be 10.8 degrees (round up to 11). If there are a number of sources that each account for 2% or less of the total, you may want to lump these into one category called "other sources."
- Make sure to label each poster "Sources of __________ in the United States," "Sources of ________ in North Carolina," or "Sources of __________ in _________County."
- Include a legend explaining identifying each category, and listing some specific sources in that category. (You can click on the source categories under each bar graph on the EPA website given above to find out specific sources. Example: Dust – unpaved roads, paved roads, construction.) Include illustrations if you like.

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- In your group, discuss the differences and similarities among the pie charts for the United States, North Carolina, and your county. Come up with several reasons to explain the similarities and differences.

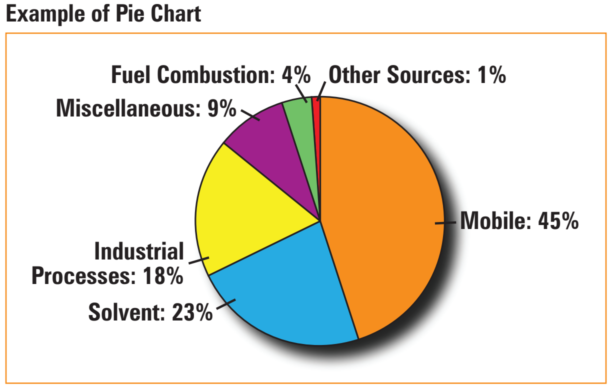
5. WRITE 1-PAGE SUMMARY

- As a group, write a one-page paper comparing and contrasting your three pie charts. If the same category accounts for the largest share of emissions in each pie chart, explain why, using your knowledge of how the pollutant is produced. If there are significant differences among the charts, explain those as well.

6. SHARE FINDINGS

- Choose a representative from your group to share your finding with the class discussing the similarities and differences in the sources for your assigned pollutant in the United States, your state, and your county and possible reasons for those similarities and differences.

Example of Pie Chart



Module 2: Activity 1

What's an Air Quality Index?

IT'S OUR AIR

SUMMARY

In this activity, students will learn where they can find the daily Air Quality Index (AQI) forecast and how to interpret it. They will also identify seasonal patterns for ozone and particulate matter in their region, and learn some of the reasons behind those patterns.

ESSENTIAL QUESTIONS

- What is an air quality index (AQI)?
- Where can I find air quality forecasts and measured concentrations of pollutants?
- What are some seasonal patterns for ozone and particulate matter in my community?

TIME NEEDED

- 5-10 minutes a day for one week for Part A, prior to doing Parts B and C
- One block period or two traditional periods for reviewing Part A and doing Parts B and C

North Carolina ESSENTIAL STANDARDS FOR EARTH/ENVIRONMENTAL SCIENCE

- EEn.2.5 Understand the structure of and processes within our atmosphere.
- EEn.2.5.1 Summarize the structure and composition of our atmosphere.
- EEn.2.5.5 Explain how human activities affect air quality.

MAKING CONNECTIONS

In this activity, students will learn that the Air Quality Index (AQI) is tool to communicate levels of air pollution to the public. The AQI is a color-coded index with numbers. It's easy to assume the numbers on the AQI are measured concentrations. While each number on the AQI does correspond to a particular measured concentration (a different concentration for each pollutant), the AQI numbers by themselves are not measured concentrations.

The AQI can be compared to movie or video-game ratings. A movie can be rated R for different reasons (violence or language or sexual content) just as a day can be "rated" Code Orange for different reasons (ozone or particulate matter or other pollutants). The AQI can also be compared to grades. A school system has a standardized scale where each letter grade corresponds to a range of number grades: A=93-100, for example. Looking at the report card, you can compare the student's work in different classes because all the teachers are using the same scale.

BACKGROUND

In North Carolina, meteorologists at the Division of Air Quality forecast the air quality every day to help inform citizens how good or bad the air quality is expected to be. The forecast is communicated using the color-coded Air Quality Index (AQI). Knowing how much air pollution is in the air helps people take precautionary steps to protect their health, such as limiting outdoor activity during times when air pollution is higher. One of the biggest air quality problems in North Carolina is ground-level ozone, a strong respiratory irritant that can cause serious health problems. Particulate matter, or particle pollution, can also be a problem in North Carolina. For more information on health problems caused by ozone and particulate matter, see Activity 1 in Module 3.

AIR QUALITY INDEX (AQI)

Air pollution can make it hard to breathe and can cause or exacerbate many health problems, from asthma to cardiovascular disease. For each pollutant, the U.S. Environmental Protection Agency (EPA) has established national air quality standards to protect public health. The states are required to address these.

The Air Quality Index (AQI) is a numerical index that quickly communicates information to the public about the presence and amount of air pollution where they live. It is used all across the United States. In North Carolina, meteorologists at the Division of Air Quality forecast the AQI each day by assessing the actual observed measurements of different pollutants along with meteorological conditions. The Division of Air Quality also keeps track of the actual observed measurements of different pollutants each day and reports and archives those measurements.

The numbers and corresponding colors of the AQI indicate relative health risk. The index goes from 0-500. One of the advantages of the AQI is that it uses the same "yardstick" to communicate about different pollutants that are measured in different units. It's a comprehensive index that accounts for multiple air pollutants and creates a simple and straightforward assessment of the air quality conditions for a region regardless of differences in pollutant units or EPA standards for different pollutants.

If a particular pollutant is mentioned following the AQI, it means that pollutant is expected to have the highest AQI. This is useful for people with specific health conditions that make them more susceptible to a particular pollutant. For example, if the AQI forecast is given as "149 ozone," it means forecasters are expecting a level of ozone that corresponds to "unhealthy for sensitive groups," and that other pollutants are expected to be lower than 149.

Air Quality Index and Health Messages

Air Quality Index	Guidelines to protect your health
Good: Code Green 0-50	No health affects expected
Moderate: Code Yellow 51-100	Usually sensitive people consider limiting prolonged or heavy exertion outdoors.
Unhealthy for Sensitive Groups: Code Orange 101-150	Children, active people, older adults, and those with heart or lung disease (like asthma): limited prolonged or heavy exertion outdoors.
Unhealthy: Code Red 151-200	Children, active people, older adults, and those with heart or lung disease (like asthma): avoid prolonged or heavy exertion outdoors.
Very Unhealthy: Code Purple 201-300	Everyone: avoid all outdoor exertion.

Source: http://www.airnow.gov/index.cfm?action=aqibasics.aqi

THE AQI **COLOR CODES**

To help the public interpret the AQI, different colors represent each range on the index. Each range/color corresponds to a particular public health message. The AQI's color code gives general information about air quality – Code Green is good and Code Purple is very unhealthy. For some people, that's enough information. But people who have asthma or other health conditions might need more information when planning their outdoor activities. In that case, they can look at the AQI number to see whether a forecasted Code Yellow day is expected to be "just barely Code Yellow" (AQI 51) or "almost Code Orange" (AQI 100).

WHAT DO AQI **NUMBERS MEAN?**

Note that the numbers on the AQI are not measured concentrations. An AQI number does not have a unit, whereas a measurement does. Measurements of ozone are usually given in parts per million (ppm) or parts per billion (ppb). Particulate matter (also called particle pollution) is measured in micrograms per cubic meter ($\mu g/m^3$).

However, the AQI number does correlate to a specific measured concentration, which is different for each pollutant. For example, an AQI value of 50 equates to an ozone concentration of 59 ppb or to a PM2.5 concentration of 12.0 $\mu g/m^3$.

The table below shows PM2.5 measurements and ozone measurements as they relate to the AQI. PM2.5 means particulate matter that is smaller than 2.5 microns in diameter. For PM2.5, the measurements are averaged over the course of 24 hours. For ozone, the measurements are averaged over the course of 8 hours. (Tip: It's particularly easy to confuse 8-hour ozone measurements in ppb and the corresponding AQI numbers because they are in similar ranges, so when working with data remember to double-check whether you're looking at ozone measurements in ppb or AQI numbers with no units.)

An AQI value over 100 surpasses the EPA daily health standard for that pollutant. For example, 35.5 $\mu g/m^3$ of PM2.5 (averaged over 24 hours) exceeds the EPA daily health standard and is equivalent to 101 on the AQI.

The Clean Air Act requires the EPA to periodically evaluate the health standards for air quality. The standards may then be adjusted to reflect the new understanding of air pollution and health. The colors, numbers and recommended actions on the AQI stay the same although the pollution measurements that correspond to the colors and numbers may change. This allows communication about air quality to the public to remain consistent. When a new, lower standard is issued by the EPA, you may see more Code Yellow, Orange, or Red days than in previous seasons because of the more stringent standard.

PM2.5 and Ozone Measurements and the AQI

Air Quality Index	24-Hour PM 2.5	8-Hour Ozone
Good 0-50 Code Green	0-12 $\mu g/m^3$	0-59 ppb
Moderate 51-100 Code Yellow	12.1-35.4 $\mu g/m^3$	60-75 ppb
Unhealthy for Sensitive Groups: 101-150 Code Orange	35.5-55.4 $\mu g/m^3$	76-95 ppb
Unhealthy 151-200 Code Red	55.5-150.4 $\mu g/m^3$	96-115 ppb
Very Unhealthy 201-300 Code Purple	150.5-250.4 $\mu g/m^3$	116-374 ppb

Source: http://daq.state.nc.us/monitor/aqi/codeChart.shtml

WHERE TO FIND AQI FORECASTS AND REPORTS

AQI forecasts and reports are available from the Division of Air Quality online at www.ncair.org/airaware/forecast. You can view the forecast and reports for both ozone and PM2.5. Choose from the tabs at the top that say, "Previously Observed," "Today's Forecast," and "Tomorrow's Forecast." You can also hear a forecast by calling 1-888-RU4-NCAIR (1-888-784-6224).

Your local newspaper, TV station, or news website may also give AQI forecasts and reports, although the forecasts and reports may include only the pollutant with the highest AQI.

SEASONAL PATTERNS OF OZONE AND PARTICULATE MATTER

Typically, ozone is more of a problem in the summer because sunlight and heat are two important ingredients in the formation of ground-level ozone, in addition to emissions of nitrogen oxides (NO_x) and volatile organic compounds. Ozone is forecast from April 1 to October 31. (See Activity 4 in Module1: "The Criteria Pollutants and a Closer Look at Ozone" for more information on both ozone and particulate matter.)

In North Carolina, particulate matter concentrations also tend to be highest during the summer months, primarily because humidity levels are higher: Water droplets aid in the formation and accumulation of particulate matter. Additionally, air masses tend to stagnate in the summer because upper level winds are weaker, so there are fewer cold fronts coming through. Cold fronts bring pristine air masses from less populated and ultimately less polluted regions, such as Canada. These clean air masses pass through much more frequently in the spring, fall, and winter, sweeping out elevated levels of particulate matter. Although concentrations of particulate matter tend to be highest in the summer, the levels don't fall as much in the other seasons as the levels of ozone do, because the formation of particulate matter is not as dependent on sunlight.

Particulate matter can be a problem locally in the fall or winter when people burn leaves in the yard or burn wood for heating. Also, temperature inversions – where a layer of cold air is trapped under a layer of warm air – are more common in the winter in North Carolina, and the lack of mixing can lead to a build-up of particles near the ground. These short-lived particle events can have noticeable impacts on people with asthma or other respiratory problems.

MATERIALS

- AQI charts for projection (included)
- Daily newspaper and/or internet connection
- Archived records of ozone and particulate matter, available online at http://www.epa.gov/airdata/

WARMUP

Review the AQI with your students, covering the colors, numbers and health messages. AQI charts for projections provided on page 8. Use one or more of the analogies given in "Making Connections" to get across the idea that the AQI number is not a measurement, although each number does correspond to a measurement (a different measurement for each pollutant).

Teacher Tips

This is a great activity to begin while the class is working on a daily weather log. While students are gathering data each day on temperature, relative humidity, dew point, etc. from around campus, have them write down the daily AQI forecasts and AQI reports as described in Part A. They may not know what the numbers mean yet, but they will have a lot of weather data, experience and background knowledge to use when you are ready to answer the questions on the rest of the Air Quality Index activity.

Remember that Part A takes one week (a few minutes each day), so have students get started on that one week before you plan to do this activity in class. For less advanced classes, on the day of the activity, have students do Part B, then review the answers to that as well as the answers to the questions from Part A together before they move on the Part C. More advanced classes could do Part B as homework the night before doing Part C in class.

– Mark Townley

THE ACTIVITY

PART A: Recording AQI Forecast and Actual AQI for One Week

1. Every day for a week, use the chart below to record air quality forecasts from the local newspaper, TV news, news website, or from the Division of Air Quality (DAQ) (www.ncair.org/airaware/forecast). If using the DAQ website, be aware that the forecast for the following day is typically posted about 3 p.m. After the first day, and for each following day, check back and see what the AQI was for the previous day and fill out the "Actual AQI" portion of the table. (Note that ozone is not forecast between November and March.)

Table Comparing Forecast and Actual AQI

Location:				
	Forecast AQI		Actual AQI	
Date	For Ozone	For PM	For Ozone	For PM

2. Answer the following questions:
- Which pollutant was more of a problem during this time period – ozone or particulate matter?
- How accurate were the forecasts?
- Were there any days where the forecast color code was different than the reported color code? If so, what might have contributed to the discrepancy? (Tip: On the website www.ncair.org/airaware/forecast, click on "forecast discussion" on the left to see what Division of Air Quality meteorologists are saying about the forecast.)

PART B: Calculating AQI

Fill in the blanks in this table, using the AirNow AQI calculators at http://www.airnow.gov/index.cfm?action=resources.aqi_conc_calc and http://www.airnow.gov/index.cfm?action=resources.conc_aqi_calc

Pollutant	Measurement with Units	AQI Number	Color Code
Ozone, 8-hour		71	
PM2.5, 24-hour	12 $\mu g/m^3$		
Ozone, 8-hour	101 ppb		
PM2.5, 24-hour		71	
Ozone, 8-hour		49	
PM2.5, 24-hour	51 $\mu g/m^3$		

Answer Key

Pollutant	Measurement with Units	AQI Number	Color Code
Ozone, 8-hour	[66 ppb]	71	[Code Yellow]
PM2.5, 24-hour	12 $\mu g/m^3$	[50]	[Code Green]
Ozone, 8-hour	101 ppb	[164]	[Code Red]
PM2.5, 24-hour	[21.6 $\mu g/m^3$]	71	[Code Yellow]
Ozone, 8-hour	[58 ppb]	49	[Code Green]
PM2.5, 24-hour	51 $\mu g/m^3$	[139]	[Code Orange]

PART C: Looking for AQI Patterns

1. Look at a whole year's worth of ozone and PM2.5 data from a monitor in your town or nearby. To obtain ozone and PM2.5 data, go to http://www.epa.gov/airdata/. Click on "download data" then choose "daily data." Specify the pollutant, year, and monitor location. If you live in a small town, look for your county on the "select a county" bar or choose a nearby city from the "select a city" bar. "Exceptional events" include wildfires or other natural disasters; most years do not have exceptional events.

   PLEASE NOTE:
   - The data will be downloaded as an Excel spreadsheet. Make sure it contains a full year's worth of data; if not, choose an earlier year. (Remember that ozone is monitored from April 1-October 31, while PM is monitored all year.)
   - On the PM2.5 spreadsheets, the data at the top of the spreadsheet is from every third day; don't use this data. Instead, scroll down past the first 125 or so rows to get to the daily data (the Parameter Code in Column I reads 88502 for daily data).

2. Fill in the table below using the AQI chart provided to assign colors to the measured concentrations of ozone and PM2.5.

Table Showing Number of Code Yellow/Orange/Red AQI Days Per Month

Location: ________________________________ Year: _________

Month	Number of Days with Code Yellow/Orange/Red AQI for Ozone			Number of Days with Code Yellow/Orange/Red AQI for PM2.5		
	Yellow	Orange	Red	Yellow	Orange	Red
January	N/A	N/A	N/A			
February	N/A	N/A	N/A			
March	N/A	N/A	N/A			
April						
May						
June						
July						
August						
September						
October						
November	N/A	N/A	N/A			
December	N/A	N/A	N/A			

3. Answer the following questions:
- What two months have the highest number of days with ozone AQIs that are Code Yellow or above?
- Explain why this might be so given your knowledge of how ground-level ozone forms.
- Is there a time of year when particle pollution seems to be the worst? If so, what time of year?
- Why do you think that particle pollution was worse at that time of year, or if there was no pattern, why do you think that was?
- Do you think your answers to the questions above would be different if you'd had more than one year's worth of data to look at? Explain.

WRAP UP AND ACTION

Have students imagine that they have asthma that is made worse when the AQI is orange or above. What strategy would they use to monitor air quality forecasting? Would they look at the forecast every day? Only during certain times of the year? What actions would they take in response to different air quality forecasts?

If you are not planning to do the next two activities in this module ("Making a Simple Predictive Model for Ozone" and "Forecasting Air Quality"), show your class the video "What is IN the Air?" It reviews AQI and air quality forecasting. It includes interviews with a doctor who studies the health effects of air pollution and with meteorologists at the Division of Air Quality.

ASSESSMENT

HAVE STUDENTS:

- Explain in writing how the AQI helps protect public health.
- Put together a brochure intended for the general public that explains the Air Quality Index. The brochure should include information about both ozone and particulate matter.
- Share your brochures with other classes, school administration and/or the community to help educate them about air quality.

EXTENSIONS

Sign up for daily emails about the AQI forecast at www.enviroflash.info/ and post the forecasts in the classroom each day. Have students come up with a list of audiences in the school that might need to know this information (such as coaches and physical education teachers), and ways to communicate the AQI to those audiences daily.

Using the year of AQI data, have students produce bar graphs (one for ozone, one for PM2.5) showing the percentages of Code Green/Yellow/Orange/Red days for each month.

RESOURCES

Explanation of AQI from AirNow, a program of the EPA and other agencies: http://www.airnow.gov/index.cfm?action=aqibasics.aqi

Air quality forecast and discussion from the N.C. Division of Air Quality: www.ncair.org/airaware/forecast.

Current readings of pollutants and archives for many monitoring sites in North Carolina: http://daq.state.nc.us/monitor/

Warm Up Page #1

Air Quality Index and Health Messages

Air Quality Index	Guidelines to protect your health
Good: Code Green 0-50	No health affects expected
Moderate: Code Yellow 51-100	Usually sensitive people consider limiting prolonged or heavy exertion outdoors.
Unhealthy for Sensitive Groups: Code Orange 101-150	Children, active people, older adults, and those with heart or lung disease (like asthma): limited prolonged or heavy exertion outdoors.
Unhealthy: Code Red 151-200	Children, active people, older adults, and those with heart or lung disease (like asthma): avoid prolonged or heavy exertion outdoors.
Very Unhealthy: Code Purple 201-300	Everyone: avoid all outdoor exertion.

Source: http://www.airnow.gov/index.cfm?action=aqibasics.aqi

Warm Up Page #2

PM2.5 and Ozone Measurements and the AQI

Air Quality Index	24-Hour PM 2.5	8-Hour Ozone
Good 0-50 Code Green	0-12 $\mu g/m^3$	0-59 ppb
Moderate 51-100 Code Yellow	12.1-35.4 $\mu g/m^3$	60-75 ppb
Unhealthy for Sensitive Groups: 101-150 Code Orange	35.5-55.4 $\mu g/m^3$	76-95 ppb
Unhealthy 151-200 Code Red	55.5-150.4 $\mu g/m^3$	96-115 ppb
Very Unhealthy 201-300 Code Purple	150.5-250.4 $\mu g/m^3$	116-374 ppb

Source: http://daq.state.nc.us/monitor/aqi/codeChart.shtml

IT'S OUR AIR

What's an Air Quality Index?

Student Page #1

THE ACTIVITY

PART A: Recording AQI Forecast and Actual AQI for One Week

1. Every day for a week, use the chart below to record air quality forecasts from the local newspaper, TV news, news website, or from the Division of Air Quality (DAQ) (www.ncair.org/airaware/forecast). If using the DAQ website, be aware that the forecast for the following day is typically posted about 3 p.m. After the first day, and for each following day, check back and see what the AQI was for the previous day and fill out the "Actual AQI" portion of the table. (Note that ozone is not forecast between November and March.)

Table Comparing Forecast and Actual AQI

Location:				
	Forecast AQI		Actual AQI	
Date	For Ozone	For PM	For Ozone	For PM

2. Answer the following questions:

- Which pollutant was more of a problem during this time period – ozone or particulate matter?
- How accurate were the forecasts?
- Were there any days where the forecast color code was different than the reported color code? If so, what might have contributed to the discrepancy? (Tip: On the website www.ncair.org/airaware/forecast, click on "forecast discussion" on the left to see what Division of Air Quality meteorologists are saying about the forecast.)

Air Quality Index and Health Messages

Air Quality Index	Guidelines to protect your health
Good: Code Green 0-50	No health affects expected
Moderate: Code Yellow 51-100	Usually sensitive people consider limiting prolonged or heavy exertion outdoors.
Unhealthy for Sensitive Groups: Code Orange 101-150	Children, active people, older adults, and those with heart or lung disease (like asthma): limited prolonged or heavy exertion outdoors.
Unhealthy: Code Red 151-200	Children, active people, older adults, and those with heart or lung disease (like asthma): avoid prolonged or heavy exertion outdoors.
Very Unhealthy: Code Purple 201-300	Everyone: avoid all outdoor exertion.

Source: http://www.airnow.gov/index.cfm?action=aqibasics.aqi

PART B: Calculating AQI

Fill in the blanks in this table, using the AirNow AQI calculators http://www.airnow.gov/index.cfm?action=resources.aqi_conc_calc and http://www.airnow.gov/index.cfm?action=resources.conc_aqi_calc

Pollutant	Measurement with Units	AQI Number	Color Code
Ozone, 8-hour		71	
PM2.5, 24-hour	12 $\mu g/m^3$		
Ozone, 8-hour	101 ppb		
PM2.5, 24-hour		71	
Ozone, 8-hour		49	
PM2.5, 24-hour	51 $\mu g/m^3$		

IT'S OUR AIR

What's an Air Quality Index?

Student Page #3

PART C: Looking for AQI Patterns

1. Look at a whole year's worth of ozone and PM2.5 data from a monitor in your town or nearby. To obtain ozone and PM2.5 data, go to http://www.epa.gov/airdata/. Click on "download data" then choose "daily data." Specify the pollutant, year, and monitor location. If you live in a small town, look for your county on the "select a county" bar or choose a nearby city from the "select a city" bar. "Exceptional events" include wildfires or other natural disasters; most years do not have exceptional events.

   PLEASE NOTE:
   - The data will be downloaded as an Excel spreadsheet. Make sure it contains a full year's worth of data; if not, choose an earlier year. (Remember that ozone is monitored from April 1-October 31, while PM is monitored all year.)
   - On the PM2.5 spreadsheets, the data at the top of the spreadsheet is from every third day; don't use this data. Instead, scroll down past the first 125 or so rows to get to the daily data (the Parameter Code in Column I reads 88502 for daily data).

2. Fill in the table below using the AQI chart provided on Student Page #4 to assign color codes to the measured concentrations of ozone and PM2.5.

Table Showing Number of Code Yellow/Orange/Red AQI Days Per Month

Location: ______________________________ **Year:** __________

Month	Number of Days with Code Yellow/Orange/Red AQI for Ozone			Number of Days with Code Yellow/Orange/Red AQI for PM2.5		
	Yellow	Orange	Red	Yellow	Orange	Red
January	N/A	N/A	N/A			
February	N/A	N/A	N/A			
March	N/A	N/A	N/A			
April						
May						
June						
July						
August						
September						
October						
November	N/A	N/A	N/A			
December	N/A	N/A	N/A			

PART C: Looking for AQI Patterns (continued)

3. Answer the following questions:

- What two months have the highest number of days with ozone AQIs that are Code Yellow or above?
- Explain why this might be so given your knowledge of how ground-level ozone forms.
- Is there a time of year when particle pollution seems to be the worst? If so, what time of year?
- Why do you think that particle pollution was worse at that time of year, or if there was no pattern, why do you think that was?
- Do you think your answers to the questions above would be different if you'd had more than one year's worth of data to look at? Explain.

PM2.5 and Ozone Measurements and the AQI

Air Quality Index	24-Hour PM 2.5	8-Hour Ozone
Good 0-50 Code Green	0-12 $\mu g/m^3$	0-59 ppb
Moderate 51-100 Code Yellow	12.1-35.4 $\mu g/m^3$	60-75 ppb
Unhealthy for Sensitive Groups: 101-150 Code Orange	35.5-55.4 $\mu g/m^3$	76-95 ppb
Unhealthy 151-200 Code Red	55.5-150.4 $\mu g/m^3$	96-115 ppb
Very Unhealthy 201-300 Code Purple	150.5-250.4 $\mu g/m^3$	116-374 ppb

Source: http://daq.state.nc.us/monitor/aqi/codeChart.shtml

Module 3: Activity 2

Personal Choices at Home to Prevent Air Pollution

IT'S OUR AIR

SUMMARY

Students explore how personal choices related to energy usage can reduce air pollution and save money. They calculate the emissions of sulfur dioxide and nitrogen oxides due to the use of electricity and natural gas by a homeowner, then evaluate the effectiveness of different strategies to reduce those emissions, including changing behavior and increasing efficiency through home renovations and/or new energy-efficient appliances.

ESSENTIAL QUESTIONS

- What choices can I make that will prevent air pollution?
- Are personal actions necessary and/or sufficient to help solve environmental problems related to air pollution?

TIME NEEDED

This activity will take about one block period (90 minutes) for AP and Honors earth science classes (assuming they do Part A as homework the night before). For academic earth science classes, doing Parts A-D in class will take about two block periods (180 minutes).

North Carolina ESSENTIAL STANDARDS FOR EARTH/ENVIRONMENTAL SCIENCE

- EEn.2.5.5 Explain how human activities affect air quality.
- CE.PFL.1 Analyze the concepts and factors that enable individuals to make informed financial decisions for effective resource planning.

A product of the NC Air Awareness Program 2016.

MAKING CONNECTIONS

How do we as a society solve problems that affect everyone? In almost all cases, we rely on a combination of government action, nonprofit organizations, civic and social groups, and personal choice. Take public safety, for example: the government provides laws, police officers enforce laws, and most citizens do their part by following the rules and reporting wrongdoers. Nonprofit organizations and civic and social groups may become involved to introduce new laws or change old ones.

Environmental problems such as air and water pollution affect everyone. Each of these issues has some laws and governmental resources dedicated to them, and citizens also make a difference through personal actions (see Module 3, Activity 4 for more information about air quality regulations). The amount of choice we have may vary. Think about water for example. You may not have a choice about where the city obtains the water that comes out of your tap. If you are an apartment dweller, you may not have a choice about how much water the appliances and fixtures in the apartment use. But you do have a choice about how much water you use, and your choices do make a difference in your water bill and in the water security of your community. The same principles apply to energy use. You may not have a choice as to which fuels are available to houses in your neighborhood or which fuels are available in a house or apartment that you rent. But you do have choices about how much energy you use in your home. And your choices can have lasting impacts.

Another connection this activity makes is with economics and the idea of cost-benefit analysis. Some energy-saving strategies are free (adjusting the thermostat), but others require money (adding insulation to your house). Analyzing the costs alongside the benefits – money saved, increased comfort at home, reduced emissions of air pollutants, the satisfaction of saving energy – can help with decision-making. Students can apply cost-benefit analyses to many aspects of their lives, not just energy usage.

BACKGROUND

Air pollution causes or exacerbates many serious health problems, including cardiovascular disease, asthma, and chronic obstructive pulmonary disease (COPD). Even in people without these types of conditions, it can impair or reduce lung function. One way to reduce air pollution is to save energy, because most of the energy we use in the United States involves the combustion of fossil fuels. This results in the emission of air pollutants including sulfur dioxide, nitrogen oxides, particulate matter, and more. For more information on combustion and air pollution, see "Combustion Equations" (Module 1, Activity 2). For more information on sulfur dioxide and nitrogen oxides, see "Criteria Pollutants and a Closer Look at Ozone" (Module 1, Activity 4).

In this activity, students will look at some ways of reducing emissions of sulfur dioxide and nitrogen oxides by saving energy at home.

ENERGY AND ELECTRICITY

In physics, energy is the ability to do work. In daily usage, the word energy means the power to accomplish something: "I don't have the energy to finish my homework." or "My hot water heater died and I want to buy one that uses less energy." In *It's Our Air*, energy generally refers to resources used to power lights, appliances, air conditioners, furnaces, and vehicles. This energy can take many forms. A few examples: a hot water heater that runs on natural gas, a wood stove that burns wood, a furnace that uses oil, an air conditioner that's powered by electricity, a car that runs on gas. Thinking back a generation or two, mills were powered by the energy of rivers, and wagons were powered by horses or oxen.

Electricity is a type of energy that consists of electrons flowing from one atom to another. Electric power plants use generators to push electrons to homes, businesses, and industries through power lines. Electricity can be generated in many ways: by burning fossil fuels such as coal or natural gas, through nuclear fission, or by harnessing the power of the sun, wind, or water.

For more information about energy, electricity, units, and emissions, see the handout entitled "Energy, Electricity, Emissions, and Units."

In this activity, Parts A and B include information about both electricity and natural gas used in the home, while Parts C and D relate only to electricity. An interesting aspect of electricity is that it can be generated from a wide variety of fuels, including coal, natural gas, wind, solar, hydroelectricity, and nuclear. The type and amount of air pollution emitted by electricity generation varies greatly, depending on the mix of fuels used in a particular region. Burning fossil fuels emits sulfur dioxide and nitrogen oxides, while generating electricity from wind, solar, hydroelectricity, or nuclear emits none of these pollutants.

As stated above, electricity is typically generated at a central power plant. (There are exceptions, such as photovoltaic panels, wind generators and emergency generators that generate electricity where it is to be used.) The advantage of central generation is that emissions can be controlled and captured at that central location. Contrast this to trying to reduce air pollution from millions of individual residential furnaces. A disadvantage is that the transmission of electricity from the power plant to homes and businesses is not completely efficient: about 6% of the electricity is lost en route, which is called line loss.

ENERGY CHOICES AT HOME

Every house is different in terms of the type of energy used, the efficiency of the appliances, and the quality of the construction in terms of insulation and air leakage. However, there are opportunities to use less energy in any home, and doing so will save money and improve air quality.

Some houses are all-electric, while others use two or more types of energy. Space heating can be accomplished by electric heat pumps, electric baseboard heaters, natural gas furnaces, woodstoves, oil furnaces, passive solar design, geothermal heat pumps, just to name a few of the possibilities. Some appliances are almost always powered by electricity, including air conditioners, lights, electronics, refrigerators, washing machines, and dishwashers. Other appliances can be powered by either electricity or natural gas – such as hot water heaters, clothes dryers, and stoves. (All three can be powered by solar as well – think clothes lines and solar camping ovens.)

Homeowners have some choice as to the fuels they use, but not complete freedom. For example, if there are no natural gas lines in your neighborhood, you can't have a gas stove. Renters may have even less choice.

However, no matter what type of energy is used at home, people can make choices that result in reduced emission of air pollutants. Individuals can choose to use less energy (turn off lights in unoccupied rooms), purchase more efficient equipment (a more efficient refrigerator), make energy-efficient renovations (adding insulation or weather-stripping) or use alternative energy sources (using a solar clothes dryer – a clothes line).

STRATEGIES TO REDUCE ENERGY USE AND AIR POLLUTION

It's often hard to know which actions will make the biggest difference, or which actions affect which pollutants. Folks might know what their average monthly electric or gas bill is in dollars, but they may not have a good idea of how many kilowatt-hours of electricity or therms of natural gas they use... or the amount of air pollution emissions that results from that use. Furthermore, many people don't have a good idea of what percentage of an energy bill is due to a particular appliance. Lacking that knowledge, it's hard to know what would be the best ways to save energy (and money) and to prevent the emission of air pollutants.

A good place to start is to look at the biggest energy users in the home. In most homes, space conditioning (heating and cooling) is the largest energy expenditure, followed by hot water heating. Heating and cooling accounts for as much as half of the energy usage of a home according to the EPA at www.energystar.gov. Good strategies for reducing overall home energy usage include keeping the thermostat at a reasonable level, replacing outdated furnaces or air conditioners with new energy-efficient models, and adding insulation or replacing old, leaky windows.

SAVING ENERGY = SAVING MONEY

An added benefit of saving energy is saving money. Some ways of saving energy, such as turning off lights or running the air conditioner less often, don't cost anything to implement. Other strategies, such as replacing an old water heater with a new energy-efficient one, cost money up front, but save on energy bills each month. In fact, the amount saved each month can gradually add up to the purchase price of the new appliance. It's a rare example of how spending money can save you money. The length of time it takes for the monthly savings to equal the purchase price is called the "payback period." While some people like to have a payback period of 10 years or less, other people enjoy the feeling of saving energy and preventing pollution and are not bothered by a longer payback period.

OTHER WAYS OF REDUCING AIR POLLUTION THROUGH PERSONAL CHOICES

This activity is about energy use and choices at home, but of course personal choice can impact air pollution with regard to other activities. Driving cars and using gasoline-powered lawn mowers emit air pollution, so driving less or purchasing a more efficient car or mower can reduce air pollution (see Module 3, Activity 3). We can also reduce particle pollution by limiting the use of fireplaces, woodstoves, and cooking grills, and refraining from burning yard waste or trash (burning trash is illegal), as well as reducing our use of energy that comes from burning fossil fuels.

ENERGY UNITS

On bills, electricity is typically measured in kilowatt-hours (kWh) and natural gas use is typically measured in therms. In order to compare electric usage to natural gas usage, both of these units can be converted to an energy unit called a British thermal unit (Btu). One Btu is the amount of energy it takes to heat or cool one pound of water one degree Fahrenheit. For a more thorough summary of energy units, see the handout titled "Energy, Electricity, Emissions, and Units."

Converting kWh and Therms to Btu

	Unit on Energy Bill	What's It Mean?	How Many Btu?
Electricity	Kilowatt-hour (kWh)	Number of kilowatts of energy used in one hour	1kWh=approx. 3,412 Btu
Natural Gas	Therm	Approximately 100 cubic feet of natural gas	1 therm=100,000 Btu

Source: www.eia.gov/tools/faqs/faq.cfm?id=45&t=8

MATERIALS

- Sample electric bill (provided)
- Sample natural gas bill (provided)
- Home energy use data (provided)
- Calculators
- Optional: data about energy use from student's home

INTRODUCTION TO SOLUTIONS/ ENERGY CHOICES VIDEO

- Introduces the three major strategies for finding solutions to air pollution: societal and personal choices, regulation, and technology.
- Reviews the history on energy in North Carolina, how our energy is produced.
- Introduces the personal choices we have in choosing how we use energy and the impact that can have on air pollution, focusing on improving energy efficiency and using less energy.

Video Length: 11:00 minutes
Key Elements: animation, interviews, video footage

WARMUP

Show the video, "Introduction to Solutions/Energy Choices Video." If practical, you could have the students watch the video at home the day before you do the activity in class.

Ask students what types of energy they use in their own homes, and if they don't know, suggest that they ask their families. This activity focuses on electricity and natural gas because they are two common sources of energy used in North Carolina. In all likelihood, the families of the students in the class use a wide variety of energy types in their homes. For example, in many parts of the state, propane and heating oil are used for heating.

If necessary, review the units of electricity (kilowatt-hours) and natural gas (therms) with your students. See the handout titled "Energy, Electricity, Energy and Units" for more information.

In a class discussion, challenge your students to come up with ways they can personally reduce air pollution. Perhaps talk through a typical daily routine, from wake-up to bedtime, and develop a list of ways we contribute to air pollution every day. Notice that most of these are related to energy use. Make the point that most of the ways we use energy involve combustion, and that combustion produces emissions of air pollutants. Discuss ways of reducing the air pollution we cause. Which ways do students think would be most significant?

Teacher Tips

This activity will be more meaningful to students who are already familiar with sulfur dioxide and nitrogen oxides.

Students can research energy and electricity, and how electricity is generated, before beginning this activity.

For AP and Honors earth science classes, give Part A as homework, then do Parts B-D in class. For academic earth science classes, do parts A-B one day and parts C-D the next. To keep students on track, stop after each part and go over the results together. If the part C calculations are too challenging, do them as a class. I put students in groups of four, and have each student become a "data expert" for one of the four parts. When students are working on Part B, but need data from Part A, the "data expert" on A can supply it.

– Mark Townley

THE ACTIVITY

PART A: Energy Bills

Imagine that you live in a house in Raleigh. You use electricity for:

- air conditioning
- refrigerator/freezer
- stove/oven
- clothes washer/dryer
- lights
- computers
- audiovisual equipment (TVs, sound systems, gaming systems, etc.)
- kitchen appliances
- other electric appliances (hair dryer, vacuum cleaner, etc.)

You use natural gas for

- space heating
- hot water

Look at the provided electricity bill and answer these questions:

1. What dates of electricity usage does this bill cover? In other words, what is the billing period? [**Answer**: March 10, 2015 – April 10, 2015]
2. How much electricity was used during the time period? Give units. [**Answer**: 528 kilowatt-hours or kWh]
3. Look at the graph on the bill. Did you use more or less electricity this month than in the same month last year? [**Answer**: more]

Look at the provided natural gas bill and answer these questions:

1. What dates of natural gas usage does this bill cover? In other words, what is the billing period? [**Answer**: March 10, 2015 – April 9, 2015]
2. How much natural gas was used during this time period. Give units. [**Answer**: 42 therms]
3. Look at the graph on the bill. Did you use more or less this month than in the same month last year? [**Answer**: less]

Energy Units

1. What units are used to measure electricity? [**Answer**: kilowatt-hours or kWh]
2. What units are used to measure natural gas? [**Answer**: therms]
3. A British Thermal Unit (Btu) is the amount of energy it takes to heat or cool one pound of water one degree Fahrenheit. Looking at the table below, how many Btu is 1 kWh? [**Answer**: approximately 3,412]
4. How many Btu is 1 therm? [**Answer**: 100,000]

TABLE 1: Converting kWh and Therms to Btu

	Unit on Energy Bill	What's It Mean?	How Many Btu?
Electricity	Kilowatt-hour (kWh)	Number of kilowatts of energy used in one hour	1kWh=approx. 3,412 Btu
Natural Gas	Therm	Approximately 100 cubic feet of natural gas	1 therm=100,000 Btu

Source: www.eia.gov/tools/faqs/faq.cfm?id=45&t=8

Table 2 shows data from one year's worth of energy bills for your house. Use the information in Table 1 to convert kWh and therms into Btu so you can compare how much of your energy use is due to electricity and how much is due to natural gas.

TABLE 2: Data from One Year of Energy Bills [ANSWER KEY]

Month of bill	Electricity Use In kWh	Electricity Use In Btu	Natural Gas In therms	Natural Gas In Btu
Jan	1,130	[3,855,560]	74	[7,400,000]
Feb	940	[3,207,280]	99	[9,900,000]
Mar	935	[3,190,220]	68	[6,800,000]
Apr	790	[2,695,480]	42	[4,200,000]
May	935	[3,190,220]	16	[1,600,000]
June	1,385	[4,725,620]	11	[1,100,000]
Jul	1,395	[4,759,740]	8	[800,000]
Aug	1,340	[4,572,080]	8	[800,000]
Sept	775	[2,644,300]	7	[700,000]
Oct	690	[2,354,280]	9	[900,000]
Nov	935	[3,190,220]	33	[3,300,000]
Dec	1,050	[3,582,600]	69	[6,900,000]
TOTAL	[12,300]	[41,967,600]	[444]	[44,400,000]

Using the data from one year's worth of energy bills, answer the following questions:

1. In which month did you use the most electricity? Why do you think that is? Do you think you would use the most electricity in that month every year? [**Answer**: July, because it's really hot so the air conditioning runs a lot. This may not be the same every year – it would depend on the weather, if we were at home or on vacation, and where we set the thermostat]
2. In which month did you use the most natural gas? Why do you think that is? [**Answer**: February, it's really cold so the heat runs a lot]
3. Approximately how many therms of natural gas do you think you use for hot water heating each month? How did you figure this out? [**Answer**: between 7 and 9 because that's how much is used in the summer when natural gas is not needed for space heating]
4. What is the total amount of energy, in Btu, used per year? [**Answer**: 86,367,600 Btu]
5. What percentage of the total energy used in the house is for heating and water heating (in other words, what percent does natural gas account for)? [**Answer**: 44,400,000/86,367,600 X 100 or 51%]
6. What percentage of the total energy used in the house is for air conditioning, appliances, electronics, and lighting (in other words, what percent does electricity account for)? [**Answer**: 41,967,600/86,367,600 X 100 or 49%]
7. Look at Table 3 showing percentages of energy consumption by end use for various regions. How does this house compare to the averages shown in the table? **Note**: You will need to add the percentages for heating and water heating in order to compare it to the data from your house. [**Answer**: It uses a slightly higher percentage for heating and water heating than the average in Georgia, and a correspondingly lower percentage on air conditioning, appliances, electronics, and lighting. On the other hand, it uses a lower percentage on heating and water heating than the U.S. as a whole, because the climate in Raleigh, North Carolina is warmer than many parts of the U.S.]

TABLE 3: Energy Consumption by End Use (Averages from Georgia, the South Atlantic region, and the U.S.)

	Georgia	South Atlantic Region	United States
Heating	30%	29%	41%
Water Heating	19%	17%	18%
Air conditioning	11%	13%	6%
Appliances, electronics, Lighting	40%	41%	35%
TOTAL	100%	100%	100%

Source: www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ga.pdf

PART B: Reducing Air Pollution

You want to help prevent air pollution by using less energy. What would be the best ways to do so? In order to decide, first you need to know something about the types and amounts of emissions of pollutants that result from using electricity and natural gas.

Emissions from Electricity

The emissions from electric generation depend on what fuels are used to generate the electricity. The mix of fuels used varies in different parts of the country. Table 4 shows the fuels used in generating electricity in North Carolina, using data from 2012. It's important to note that the mix of fuels used changes over time. You can check for updated numbers on EPA's Power Profiler website: http://oaspub.epa.gov/powpro/ept_pack.charts. (**Note**: If everyone in the class tries to use the website at the same time, it may crash. It's best to have the teacher or one student in the class go to the site, see whether the data has been updated, and if so, share the information with the rest of the class.)

TABLE 4: Mix of Fuels Used to Generate Electricity in North Carolina

Source	2012 % of total:
Nuclear	41.2%
Coal	34.8%
Natural Gas	20.2%
Renewables (not incl. hydro)	2.5%
Hydroelectric	0.9%
Oil	0.2%

Source for 2012 data: http://oaspub.epa.gov/powpro/ept_pack.charts

Emissions change with the fuel types. For example, burning coal to generate electricity produces more than three times more nitrogen oxide and 99 times more sulfur dioxide emissions as burning natural gas to produce the same amount of electricity. Generating electricity from nuclear power does not produce any emissions of sulfur dioxide or nitrogen oxides. Table 5 shows the emission factors of sulfur dioxide and nitrogen oxides from the mix of fuels used in 2012. Again, you can check for updated numbers on EPA's Power Profiler website: http://oaspub.epa.gov/powpro/ept_pack.charts. **Note**: Emission factors means the amount of emissions per unit of energy use – kWh for electricity, and therms for natural gas.

TABLE 5: Emissions of Natural Gas

Emissions of...	2012
...sulfur dioxide (SO_2)	0.0011 lbs/kWh
...nitrogen oxides (NO_X)	0.0007 lbs/kWh

Source for 2012 data: http://oaspub.epa.gov/powpro/ept_pack.charts

Emissions from Natural Gas

The emissions generated from burning natural gas, whether for a furnace, hot water heater, or stove, are as follows:

TABLE 6: Emission Factors for Natural Gas

Sulfur dioxide (SO_2)	0.00006 lbs/therm
Nitrogen oxides (NO_X)	0.0092 lbs/therm

Source: Natural Gas 1998: Issues and Trends (Energy Information Administration), Chapter 2, page 58. **Note**: 1 billion Btu = 10,000 therms. www.eia.gov/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_and_trends/it98.html

TABLE 7: SO_2 and NO_x Emissions per Year [ANSWER KEY]

	Usage Info per year	Usage in Btu per year	% of home energy use	SO_2 emissions in pounds/year	NO_x emissions in pounds/year
Electricity	[12,300] kWh	[41,967,600]	[49%]	[13.5]	[8.61]
Natural Gas	[444] therms	[44,400,000]	[51%]	[0.0266]	[4.08]

Fill in the first two columns of Table 7 using information from Table 2: Data from One Year of Energy Bills. In the third column, calculate what percentage of your total energy use is due to natural gas use (heating and hot water heating) and what percentage is due to electricity use (air conditioning, refrigerator, cooking, etc.) Using the information about emissions (shown in Tables 5 and 6), fill in the chart with the emissions of sulfur dioxide (SO_2)and nitrogen oxides (NO_x) your energy use creates each year.

Comparing Strategies to Prevent Air Pollution

Which of the strategies below do you think will prevent the most air pollution and why? Answer this question before doing the calculations.

Strategy 1: Reduce your electricity use by 10% by changing your behavior: turning off lights and appliances when not in use, occasionally using a clothesline instead of clothes dryer, and keeping your home a bit warmer in the summer (remember, your house does not use electricity for heating).

Strategy 2: Reduce your electricity use by 20% by some combination of the following: replacing your old air conditioner with a new energy-efficient air conditioner, having your duct system repaired, using a programmable thermostat, adding insulation to the attic and/or walls, sealing leaks, installing energy-efficient windows, buying a new energy-efficient refrigerator, replacing incandescent light bulbs with compact fluorescent or LED bulbs, regularly using a clothesline instead of a dryer.

Strategy 3: Reduce your natural gas use by 10% by changing behaviors: taking shorter showers, washing your clothes in cold water, and keeping your house a bit cooler in the winter.

Strategy 4: Reduce your natural gas use by 20% by some combination of the following: replacing your old furnace with a new energy-efficient one, having your duct system repaired, using a programmable thermostat, adding insulation to the attic and/or walls, sealing leaks, installing energy-efficient windows, insulating your hot water heater, buying a new energy-efficient hot water heater.

Now calculate the reduction in emissions for sulfur dioxide and nitrogen oxides for each strategy. Write your answers in Table 8.

Table 8: Reduction in Emissions per Year [ANSWER KEY]

	Strategy 1: Reduce Electricity Use by 10%	Strategy 2: Reduce Electricity Use by 20%	Strategy 3: Reduce Natural Gas by 10%	Strategy 4: Reduce Natural Gas by 20%
Reduction in sulfur dioxide (SO_2) emissions	[13.5 x 0.10 = 1.35 lbs/year]	[13.5 x 0.20 = 2.7 lbs/year]	[0.0266 x 0.10 = 0.00266 lbs/year]	[0.0266 x 0.20 = 0.00532 lbs/year]
Reduction in nitrogen oxides (NO_x) emissions	[8.61 x 0.10 = 0.861 lbs/year]	[8.61 x 0.20 = 1.722 lbs/year]	[4.08 x 0.10 = 0.408 lbs/year]	[4.08 x 0.20 = 0.816 lbs/year]

Answer the following questions:

1. Which strategy would prevent the most sulfur dioxide emissions? [**Answer**: Strategy 2: cutting electricity use by 20%]
2. Which strategy would prevent the most NO_x emissions? [**Answer**: Strategy 2: cutting electricity use by 20%]
3. Which strategies would cost the homeowner money to implement? [**Answer**: Strategies 2 and 4: cutting electricity use and/or natural gas use by buying new furnaces or air conditioners, repairing ducts, or adding insulation]
4. Which strategies would not cost the homeowner anything to implement? [**Answer**: Strategies 1 and 3: changing behavior at home]
5. Which strategies would reduce your monthly bills? [**Answer**: all of them.]
6. Why is it important to know how your electricity is generated in order to devise strategies for reducing the emission of air pollutants due to home energy use? [**Answer**: Certain fuels used in electric generation produce more emissions than others.]

PART C: Which appliances use the most electricity?

Work with a partner to rank these 18 appliances in order of how much electricity you estimate they use in one year. Use the first blank column of Table 9 to record your estimated order, putting the appliance you think uses the most kWh per year as number 1 and putting the appliance you think uses the least kWh per year as number 18.

The 18 appliances in alphabetical order:

clothes dryer
clothes washer
coffee maker
dishwasher
hair dryer
iPhone 6
lamp with a 60-watt incandescent bulb
lamp with a 13-watt compact fluorescent bulb
laptop computer
microwave
refrigerator with side-mounted freezer, and through-the-door ice
refrigerator with top-mounted freezer
television, 32-inch LED
television, 65-inch plasma
vacuum cleaner
video game on desktop computer
video game system with LCD television
water heater

TABLE 9: Yearly Electricity Use of Some Common Appliances [ANSWER KEY]

Electricity Use Rank	Estimated Order	Calculated Order: List item with its kWh/yr in parentheses
1		[water heater (4,773)]
2		[clothes dryer (684)]
3		[refrigerator with side-mounted freezer, through-the-door ice (630)]
4		[refrigerator with top-mounted freezer (383)]
5		[television, 65-inch plasma (346)]
6		[dishwasher (270)]
7		[clothes washer (196)]
8		[video game system with television (153)]
9		[video game on desktop computer (137)]
10		[hair dryer (98)]
11		[television, 32-inch LED (89)]
12		[vacuum cleaner (75)]
13		[laptop computer (71)]
14		[lamp with a 60-watt incandescent bulb (66)]
15		[microwave (49)]
16		[coffee maker (2-cup) (43)]
17		[lamp with a 13-watt compact fluorescent bulb (14)]
18		[iPhone 6 (4)]

Your teacher will distribute a card for each appliance, one to each pair of students. One person from each pair should take the card to the front of the room, and form a line with the other students, arranging yourselves in order of electricity use. Discuss with your classmates until everyone agrees on an order. The teacher will write this order on the board.

Next, check your estimated ranking by calculating the electricity use for each appliance. The data you need to do this are shown in Table 10. Large appliances, such as dishwashers or refrigerators, come with a yellow Energy Guide card that shows the estimated kWh per year, so you will not need to do calculations for the large appliances. For smaller appliances, calculate it yourself: A label on the appliance will show watts (W) used. Convert this to kilowatts (kW) by dividing by 1,000. Multiply the kilowatts by the number of hours used in a year to get kilowatt-hours (kWh) per year. Round off to the nearest whole kWh.

Example: A toaster oven uses 1,200 Watts and you use it for 3 minutes every day: 1,200 W/1000 = 1.2 kW
(3 minutes/day x 365 days/year)/60 minutes/hour = 18.25 hours/year
1.2 kW x 18.25 hours = 22 kWh per year

After you have calculated the kWh per year for the smaller appliances, fill in the last column of Table 9 with the appliances in the correct order.

TABLE 10: Data for Calculating Electricity Use [ANSWER KEY]

Appliance	Wattage	Time used per year	Electricity use per year, rounded off to nearest kWh
Clothes dryer	–	–	Energy Guide: **684 kWh per year**
Clothes washer	–	–	Energy Guide: **196 kWh per year** (based on 8 loads a week)
Coffee maker (2-cup)	700	10 minutes, 365 days a year	[0.7 kW x 60.8 hours = **43 kWh per year**]
Dishwasher	–	–	Energy Guide: **270 kWh per year** (based on 4 loads a week)
Hair dryer	1875	1 hour a week, 52 weeks a year	[1.875 kW x 1 hour x 52 weeks = **98 kWh per year**]
iPhone 6	10.5 Wh (watt-hour) per charge	365 charges per year	[10.5 Wh x 365 = **4 kWh per year**]
Lamp with a 60-watt incandescent bulb	60	3 hours a day, 365 days a year	[0.06 kW x 1,095 hours = **66 kWh per year**]
Lamp with a 13-watt compact fluorescent bulb	13	3 hours a day, 365 days a year	[0.013 kW x 1,095 hours = **14 kWh per year**]
Laptop computer	60	3.25 hours a day, 365 days a year	[0.06 kW x 1,186 hours = **71 kWh per year**]
Microwave	800	10 minutes, 365 days a year	[0.8 kW x 60.8 hours = **49 kWh per year**]
Refrigerator with side-mounted freezer, and through-the-door ice	–	–	Energy Guide: **630 kWh per year**
Refrigerator with top-mounted freezer	–	–	Energy Guide: **383 kWh per year**
Television, 65-inch plasma	–	–	Energy Guide: **346 kWh per year** (based on 5 hours of use a day)
Television, 32-inch LED	–	–	Energy Guide: **89 kWh per year** (based on 5 hours of use a day)
Vacuum cleaner	1,440	1 hour a week, 52 weeks a year	[1.440 kW x 1 hour x 52 weeks = **75 kWh per year**]
Video game system with television	Video game: 20 W LCD television: 150 W	3 hours a day, 300 days a year	[(0.020 kW + 0.150 kW) x 3 hours x 300 hours = **153 kWh per year**]
Video game on desktop computer	Computer CPU: 68 W Monitor: 84 W	3 hours a day, 300 days a year	[(0.068 kW + 0.084 kW) x 3 hours x 300 days = **137 kWh per year**]
Water heater (40 gallon)	–	–	Energy Guide: **4,773 kWh per year**

Then have representatives from each pair return to the front of the room and stand in the correct order based on the new information and calculations. As a class, discuss what you learned and whether there were any surprises.

The 18 appliances in order of electricity use:

1. water heater
2. clothes dryer
3. refrigerator with side-mounted freezer and through-the-door ice
4. refrigerator with top-mounted freezer
5. television, 65-inch plasma
6. dishwasher
7. clothes washer
8. video game system with television
9. video game on desktop computer
10. hair dryer
11. television, 32-inch LED
12. vacuum cleaner
13. laptop computer
14. lamp with 60-watt incandescent bulb
15. microwave
16. coffee maker (2-cup)
17. lamp with 13-watt compact fluorescent
18. iPhone 6

Answer the following questions:

1. Which three appliances use the most electricity? [**Answer**: water heater, clothes dryer, refrigerator/freezer]
2. Which would prevent more air pollution, drying your clothes on a clothes line about half the time or giving up video games and your coffee maker? [**Answer**: drying your clothes outside about half the time.]
3. Which would prevent more air pollution, replacing an old refrigerator with a new energy efficient one that uses about half of the electricity or installing a solar water heater with an electric back-up? [**Answer**: installing a solar water heater]

PART D: Benefits and Costs of Replacing Old Refrigerator

Imagine that your refrigerator is more than 20 years old and you want to replace it.

TABLE 11: Refrigerator Energy Use and Cost Per Year Comparison

	Features	Cost	Average energy use per year According to Energy Guide label	Average cost Per Year According to Energy Guide label
Old Refrigerator From 1990-1992	Top freezer, 19-21 cubic feet	N/A	1,285 kWh	$142.64
Refrigerator B Frigidaire FFTR1814QB (2015 model)	Top freezer, 18 cubic feet	$521	404 kWh	$48

Source: www.energystar.gov/index.cfm?fuseaction=refrig.calculator and Home Depot website.

1. How much money would you save each year on your electric bill with the new refrigerator? [**Answer**: $94.64]
2. How many years until your savings paid for the cost of the new refrigerator? This time period is called the "payback period," because at the end of it, you'll have been "paid back" for the money you spent on the new refrigerator. [**Answer**: 5.5 years]
3. What would the yearly reduction in emissions of sulfur dioxide be, assuming an emission factor of 0.0011 lbs of sulfur dioxide per kWh? [**Answer**: (1,285 – 404 kWh) x 0.0011 lbs/kWh = 0.97 lbs]
4. What would the reduction in emissions of nitrogen oxides be, assuming an emission factor of 0.0007 lbs of nitrogen oxide per kWh? [**Answer**: (1,285 – 404 kWh) x 0.0007 lbs/kWh = 0.62 lbs]
5. Imagine you have decided to keep the old fridge in the garage to hold drinks and snacks. How much would it cost each year to run both the old fridge and the new one? [**Answer**: $190.64]
6. How much sulfur dioxide emissions would result from generating the electricity need to run both refrigerators each year? [**Answer**: (1,285 + 404 kWh) x 0.0011 lbs/kWh = 1.86 lbs]
7. How much nitrogen oxide emissions would result from generating the electricity need to run both refrigerators each year? [**Answer**: (1,285 + 404 kWh) x 0.0007 lbs/kWh = 1.18 lbs]
8. After purchasing your new refrigerator, would you keep the old refrigerator in the garage for drinks and snacks or get rid of it? Explain your reasoning. [**Answer**: varies]

WRAP UP AND ACTION

Review the results of the activity together and share thoughts on which energy-saving strategies students would be most likely to use. Generate a list of effective ways students can prevent air pollution, based on the knowledge gained during this activity.

Discuss the issue of a payback period. In the example in Part D, the new refrigerator saves enough money each month compared to the old refrigerator to cover its cost in 5.5 years. In many cases, payback periods will be longer because most people are not still using 20-year old refrigerators. Is payback period the only criterion to use when choosing an appliance? Would students be willing to pay more for an energy efficient appliance with a payback period of 10 years? 15 years? 20 years? Does it make sense to replace an appliance that is not very old or worn out with an energy efficient one? Or is it better to wait until appliances need to be replaced anyway?

This is a good time to discuss the idea of cost-benefit analysis. Remember that the “cost” and the “benefit” can refer to more than just money: consider convenience, personal effort, time, improved performance, feeling of satisfaction, among others. Ask students to summarize how they applied cost-benefit analyses to the various energy choices evaluated in this activity. Can students name examples of how they apply it in other areas of their life? If their cell phone has a cracked screen, yet still works, it is worth it to pay to have the screen repaired? To pay for a new phone? What factors would go into this decision?

Discuss whether personal actions are necessary to help solve environmental problems related to air pollution. Are personal actions alone sufficient to help solve environmental problems related to air pollution? Do citizens have a responsibility to take actions to prevent pollution?

ASSESSMENT

HAVE STUDENTS:

Write an editorial for the newspaper or a blog post covering the following points:

- the connection between energy use and air pollution.
- effective ways that personal choice can be used to reduce emissions of sulfur dioxide and NO_x.

EXTENSIONS

This activity will have more meaning for students if they use data from their own lives, rather than the hypothetical data given. They can calculate emissions that result from their energy use at home and then develop specific strategies to reduce those emissions. Students can do this activity themselves if they have access to the following information:

- Electricity usage in kWh in their home over the past 12 months
- Natural gas usage in therms in their home over the past 12 months

RESOURCES

Energy units calculator

If you need to convert cubic feet of natural gas into therms, or Btu into kWh, check out this energy calculator from the Energy Information Administration:

http://tonto.eia.doe.gov/kids/energy.cfm?page=about_energy_conversion_calculator-basics

Online calculators for emissions from electricity use

Go to the Power Profiler at www.epa.gov/cleanenergy/energy-and-you/how-clean.html to find the mix of fuels used at your electric utility, and also to figure out what emissions are generated due to the electricity you use at home.

Online calculator for total home energy use

At this Energy Star website you can figure out how much energy your house uses, compare that to other homes, and get recommendations for ways of saving energy:

www.energystar.gov/index.cfm?fuseaction=HOME_ENERGY_YARDSTICK.showGetStarted

Learn how to read your home energy report and save money and energy

www.duke-energy.com/home/products/my-home-energy-report

How to estimate the amount of electricity an appliance uses per year

http://energy.gov/energysaver/articles/estimating-appliance-and-home-electronic-energy-use

An activity for students to calculate their carbon footprint:

http://erp.unc.edu/files/2013/07/Calculating_Your_Carbon_Footprint.pdf

Energy, Electricity, Emissions, and Units

What is Energy?

In physics, energy is the ability to do work. In daily usage, the word energy means the power to accomplish something: "I don't have the energy to finish my homework." or "My hot water heater died and I want to buy one that uses less energy." In It's Our Air, energy generally refers to resources used to power lights, appliances, air conditioners, furnaces, and vehicles. This energy can take many forms. A few examples: a hot water heater that runs on natural gas, a wood stove that burns wood, a furnace that uses oil, an air conditioner that's powered by electricity, a car that runs on gasoline. Thinking back a generation or two, mills were powered by the energy of rivers, and wagons were powered by horses or oxen.

What is Electricity?

Electricity is a type of energy that consists of electrons flowing from one atom to another. Electric power plants use generators to push electrons to homes, businesses, and industry through power lines. Electricity can be produced in many ways: by burning fossil fuels such as coal or natural gas, through nuclear fission, or by harnessing the power of the sun, wind, or water.

Review of Units

Joule (J): A unit of energy. It equals the force required to accelerate one kilogram at the rate of one meter per second squared through one meter of space.
$J = (kg \times m^2)/s^2$

British thermal unit (BTU or Btu): A unit of thermal (heat) energy. It is the heat required to raise the temperature of one pound of water by one degree Fahrenheit. It equals approximately 1,055 joules.

Watt (W): A unit of power. Power refers to the rate at which energy is produced or consumed. A watt is equal to 1 joule of energy per second.
$W = J/s$

Kilowatt (kW): A unit of power. It equals 1,000 watts or 1,000 joules of energy per second.

Watt-hours (Wh): A unit of energy. It is the multiplication of power in watts (joules/second) by an hour. It equals 3,600 joules.

Kilowatt-hour (kWh): A unit of energy equal to 1,000 watt-hours. It is the multiplication of power in kilowatts by an hour. A kilowatt-hour equals 3.6 megajoules (3.6 million joules). A kilowatt-hour also equals approximately 3,412 Btu.

Megawatt-hour (MWh): A unit of energy equal to 1,000 kilowatt-hours. It is the multiplication of power in megawatts by an hour.

Therm: A unit of heat. On a bill from the natural gas company, energy use is measured in "therms." One therm equals 100,000 Btu.

Emissions from Burning Natural Gas, Oil, Coal

Pounds of Pollutant per Billion Btu of Energy Input
Note: 1 billion Btu of natural gas = 10,000 therms.

Pollutant	Natural Gas	Oil	Coal
Carbon dioxide	117,000	164,000	208,000
Carbon monoxide	40	33	208
Nitrogen oxides	92	448	457
Sulfur dioxide	0.6	1,122	2,591
Particulates	7	84	2744
Mercury	0.000	0.007	0.016

Source: Natural Gas 1998: Issues and Trends (Energy Information Administration) Chapter 2, page 58.
www.eia.gov/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_and_trends/it98.html

Emissions from Generating Electricity

Different utilities use different fuels to generate electricity, depending on the resources available in that part of the country: coal and other fossil fuels, hydropower, nuclear, solar, wind, biomass, etc. For this reason, the emissions that result from generating a kilowatt-hour of electricity vary as well. The EPA Clean Energy website has a page called "Power Profiler" where you can enter your zip code and find out the mix of fuels used by your electric utility and the emissions that result: http://oaspub.epa.gov/powpro/ept_pack.charts

Energy Conversion Calculator

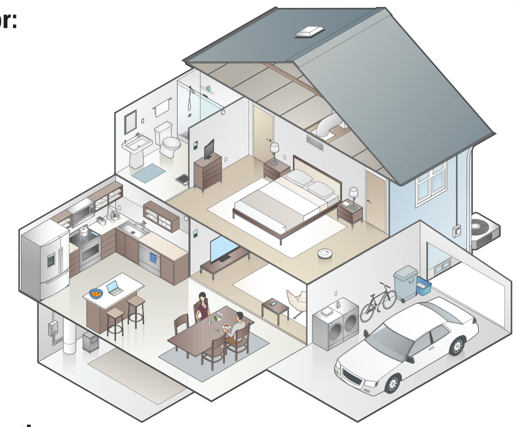
You can convert energy from one unit to another using this information on this handout. Another option is to use an online energy conversion calculator, such as this one:
www.eia.gov/kids/energy.cfm?page=about_energy_conversion_calculator-basics

PART A: Energy Bills

Imagine that you live in a house in Raleigh.

You use electricity for:
air conditioning
refrigerator/freezer
stove/oven
clothes washer/dryer
lights
computers
audiovisual equipment
(TVs, sound systems, gaming systems, etc.)
kitchen appliances
other electric appliances
(hair dryer, vacuum cleaner, etc.)

You use gas for:
space heating
hot water



Look at the provided electricity bill and answer these questions:
What dates of electricity usage does this bill cover? In other words, what is the billing period?

How much electricity was used during the time period? Give units.

Look at the graph on the bill. Did you use more or less this month than in the same month last year?

Look at the provided natural gas bill and answer these questions:
What dates of natural gas usage does this bill cover? In other words, what is the billing period?

How much natural gas was used during this time period. Give units.

Look at the graph on the bill. Did you use more or less this month than in the same month last year?

Energy Units

What units are used to measure electricity?

What units are used to measure natural gas?

A British Thermal Unit (Btu) is the amount of energy it takes to heat or cool one pound of water one degree Fahrenheit. Looking at the table below, how many Btu is 1 kWh?

How many Btu is 1 therm?

TABLE 1: Converting kWh and Therms to Btu

	Unit on Energy Bill	What's It Mean?	How Many Btu?
Electricity	Kilowatt-hour (kWh)	Number of kilowatts of energy used in one hour	1kWh=approx. 3,412 Btu
Natural Gas	Therm	Approximately 100 cubic feet of natural gas	1 therm=100,000 Btu

Source: www.eia.gov/tools/faqs/faq.cfm?id=45&t=8

Part A: Energy Bills (continued)

MY ELECTRIC COMPANY

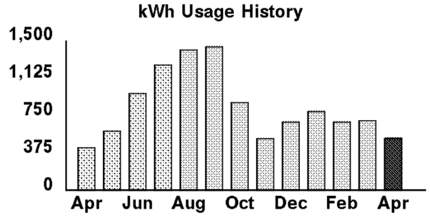
MY NAME
123 MAIN ST.
RALEIGH NC 27603-2149

Customer Bill

page 1 of 1

Account number		123 456 7890
Total due		**67.23**
Thank you for your payment	Apr 6	$100.00
Usage period		Mar 10 - Apr 10
This bill was mailed on		April 13, 2015

kWh Usage History



Usage

Meter number		EK3897
Readings: Apr	10	83617
Mar	10	- 83089
kWh usage		**528**

Days in period 31 Average kWh per day 17

Billing
Residential Service rate

	31 Days
Electric service	62.00
REPS Adjustment	0.83
7% North Carolina sales tax	4.40
Current bill amount	67.23
Balance before current bill	0.00
Amount Due on May 7,2015	67.23

MY Natural Gas COMPANY

SERVICE FOR
MY NAME
123 MAIN ST.
RALEIGH NC 27603-2149

ACCOUNT NUMBER
123 456 7890

DATE DUE
May 10, 2015

Page 1 of 2

Amount Due
48.50

CUSTOMER SERVICE - 24 HOURS A DAY
1-877-776-2427, toll-free

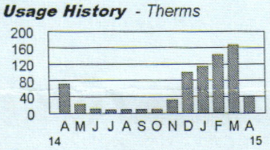
EMERGENCY SERVICE - 24 HOURS A DAY
To report gas leaks
1-877-776-2427, toll-free

STATEMENT DATE
Apr 13 2015

ACCOUNT SUMMARY

Previous Bill Amount		$ 100.00
Payment Received	04/07/15 THANK YOU	-100.00
Current Charges		48.50
	Amount Due	48.50

Gas Usage History *- Therms*



	Apr 14	Apr 15
Therms used	73	42
Avg regional temp	52	57
Days in billing period	29	30
Cost	$83.69	$45.33

For a complete set of tools to analyze your usage, log on to psncenergy.com.

CURRENT CHARGES

Gas Charges

RATE PLAN
101 - Gas- Residential

METER READING
Gas Meter read on 04/09/15 at 07:19 am
(Next scheduled read date 5/7/15)

METER NO.	BILLING PERIOD	DAYS	CURRENT	PREVIOUS	CONSTANT	USAGE (CCF)	BTU FACTOR	THERMS
000296501	03/10/15 - 04/09/15	30	1348	1307	1	41	1.0310 =	42

Basic Facilities Charge	10.00
42 Therms X $ 0.841190	35.33
State Sales Tax at 7.00 %	3.17
Total Gas Charges	**$48.50**

Part A: Energy Bills (continued)

Table 2 shows data from one year's worth of energy bills for your house. Use the information in Table 1 to convert kWh and therms into Btu so you can compare how much of your energy use is due to electricity and how much is due to natural gas.

TABLE 2: Data from One Year of Energy Bills

Month of bill	Electricity Use In kWh	Electricity Use In Btu	Natural Gas In therms	Natural Gas In Btu
Jan	1,130		74	
Feb	940		99	
Mar	935		68	
Apr	790		42	
May	935		16	
June	1,385		11	
Jul	1,395		8	
Aug	1,340		8	
Sept	775		7	
Oct	690		9	
Nov	935		33	
Dec	1,050		69	
TOTAL				

Using the data from one year's worth of energy bills, answer the following questions:

1. In which month did you use the most electricity? Why do you think that is? Do you think you would use the most electricity in that month every year?

2. In which month did you use the most natural gas? Why do you think that is?

3. Approximately how many therms of natural gas do you think you use for hot water heating each month? How did you figure this out?

4. What is the total amount of energy, in Btu, used per year?

5. What percentage of the total energy used in the house is for heating and water heating (in other words, what percent does natural gas account for)?

6. What percentage of the total energy used in the house is for air conditioning, appliances, electronics, and lighting (in other words, what percent does electricity account for)?

7. Look at Table 3 showing percentages of energy consumption by end use for various regions. How does this house compare to the averages shown in the table? **Note**: You will need to add the percentages for heating and water heating in order to compare it to the data from your house.

TABLE 3: Energy Consumption by End Use (Averages from Georgia, the South Atlantic region, and the U.S.)

	Georgia	South Atlantic Region	United States
Heating	30%	29%	41%
Water Heating	19%	17%	18%
Air conditioning	11%	13%	6%
Appliances, electronics, Lighting	40%	41%	35%
TOTAL	100%	100%	100%

Source: www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ga.pdf

PART B: Reducing Air Pollution

You want to help prevent air pollution by using less energy. What would be the best ways to do so? In order to decide, first you need to know something about the types and amounts of emissions of pollutants that result from using electricity and natural gas.

Emissions from Electricity

The emissions from electric generation depend on what fuels are used to generate the electricity. The mix of fuels used varies in different parts of the country. Table 4 shows the fuels used in generating electricity in North Carolina, using data from 2012. It's important to note that the mix of fuels used changes over time. You can check for updated numbers on EPA's Power Profiler website: http://oaspub.epa.gov/powpro/ept_pack.charts. (**Note**: If everyone in the class tries to use the website at the same time, it may crash. It's best to have the teacher or one student in the class go to the site, see whether the data has been updated, and if so, share the information with the rest of the class.)

TABLE 4: Mix of Fuels Used to Generate Electricity in North Carolina

Source	2012 % of total:
Nuclear	41.2%
Coal	34.8%
Natural Gas	20.2%
Renewables (not incl. hydro)	2.5%
Hydroelectric	0.9%
Oil	0.2%

Source for 2012 data: http://oaspub.epa.gov/powpro/ept_pack.charts

Emissions change with the fuel types. For example, burning coal to generate electricity produces more than three times more nitrogen oxide and 99 times more sulfur dioxide emissions as burning natural gas to produce the same amount of electricity. Generating electricity from nuclear power does not produce any emissions of sulfur dioxide or nitrogen oxides. Table 5 shows the emission factors of sulfur dioxide and nitrogen oxides from the mix of fuels used in 2012. Again, you can check for updated numbers on EPA's Power Profiler website: http://oaspub.epa.gov/powpro/ept_pack.charts. **Note**: Emission factors means the amount of emissions per unit of energy use – kWh for electricity, and therms for natural gas.

TABLE 5: Emission Factors for Electricity Generation in North Carolina

Emissions of...	2012
...sulfur dioxide (SO_2)	0.0011 lbs/kWh
...nitrogen oxides (NO_X)	0.0007 lbs/kWh

Source for 2012 data: http://oaspub.epa.gov/powpro/ept_pack.charts

Emissions from Natural Gas

The emissions generated from burning natural gas, whether for a furnace, hot water heater, or stove, are as follows:

TABLE 6: Emission Factors for Natural Gas

Sulfur dioxide (SO_2)	0.00006 lbs/therm
Nitrogen oxides (NO_X)	0.0092 lbs/therm

Source: Natural Gas 1998: Issues and Trends (Energy Information Administration), Chapter 2, page 58. **Note**: 1 billion Btu = 10,000 therms. www.eia.gov/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_and_trends/it98.html

Part B: Reducing Air Pollution (continued)

Fill in the first two columns of Table 7 using information from Table 2: Data from One Year of Energy Bills. In the third column, calculate what percentage of your total energy use is due to natural gas use (heating and hot water heating) and what percentage is due to electricity use (air conditioning, refrigerator, cooking, etc.) Using the information about emissions (shown in Tables 5 and 6), fill in the chart with the emissions of sulfur dioxide (SO_2)and nitrogen oxides (NO_X) your energy use creates each year.

TABLE 7: SO_2 and NO_X Emissions per Year

	Usage Info per year	Usage in Btu per year	% of home energy use	SO_2 emissions in pounds/year	NO_X emissions in pounds/year
Electricity	kWh				
Natural Gas	therms				

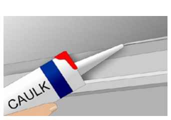
Comparing Strategies to Prevent Air Pollution

Which of the strategies below do you think will prevent the most air pollution and why? Answer this question before doing the calculations.

Strategy 1
Reduce your electricity use by 10% by changing your behavior: turning off lights and appliances when not in use, occasionally using a clothesline instead of clothes dryer, and keeping your home a bit warmer in the summer (remember, your house does not use electricity for heating).

Strategy 2
Reduce your electricity use by 20% by some combination of the following: replacing your old air conditioner with a new energy-efficient air conditioner, having your duct system repaired, using a programmable thermostat, adding insulation to the attic and/or walls, sealing leaks, installing energy-efficient windows, buying a new energy-efficient refrigerator, replacing incandescent light bulbs with compact fluorescent or LED bulbs, regularly using a clothesline instead of a dryer.

Strategy 3
Reduce your natural gas use by 10% by changing behaviors: taking shorter showers, washing your clothes in cold water, and keeping your house a bit cooler in the winter.



Strategy 4
Reduce your natural gas use by 20% by some combination of the following: replacing your old furnace with a new energy-efficient one, having your duct system repaired, using a programmable thermostat, adding insulation to the attic and/or walls, sealing leaks, installing energy-efficient windows, insulating your hot water heater, buying a new energy-efficient hot water heater.

Part B: Reducing Air Pollution (continued)

Now calculate the reduction in emissions for sulfur dioxide and nitrogen oxides for each strategy. Write your answers in Table 8.

Table 8: Reduction in Emissions per Year

	Strategy 1: Reduce Electricity Use by 10%	Strategy 2: Reduce Electricity Use by 20%	Strategy 3: Reduce Natural Gas by 10%	Strategy 4: Reduce Natural Gas by 20%
Reduction in sulfur dioxide (SO_2) emissions				
Reduction in nitrogen oxides (NO_X) emissions				

Answer the following questions:

1. Which strategy would prevent the most sulfur dioxide emissions?
2. Which strategy would prevent the most NO_X emissions?
3. Which strategies would cost the homeowner money to implement?
4. Which strategies would not cost the homeowner anything to implement?
5. Which strategies would reduce your monthly bills?
6. Why is it important to know how your electricity is generated in order to devise strategies for reducing the emission of air pollutants due to home energy use?

PART C: Which appliances use the most electricity?

Work with a partner to rank these 18 appliances in order of how much electricity you estimate they use in one year. Use the second column of Table 9 to record your estimated order, putting the appliance you think uses the most kWh per year as number 1 and putting the appliance you think uses the least kWh per year as number 18.

The 18 appliances in alphabetical order:

clothes dryer
clothes washer
coffee maker
dishwasher
hair dryer
iPhone 6
lamp with a 60-watt incandescent bulb
lamp with a 13-watt compact fluorescent bulb
laptop computer
microwave
refrigerator with side-mounted freezer, and through-the-door ice
refrigerator with top-mounted freezer
television, 32-inch LED
television, 65-inch plasma
vacuum cleaner
video game on desktop computer
video game system with LCD television
water heater

TABLE 9: Yearly Electricity Use of Some Common Appliances

Electricity Use Rank	Estimated Order	Calculated Order: List item with its kWh/yr in parentheses
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		

Your teacher will distribute a card for each appliance, one to each pair of students. One person from each pair should take the card to the front of the room, and form a line with the other students, arranging yourselves in order of electricity use. Discuss with your classmates until everyone agrees on an order. The teacher will write this order on the board.

Part C: Which appliances use the most electricity? (continued)

Next, check your estimated ranking by calculating the electricity use for each appliance. The data you need to do this are shown in Table 10. Large appliances, such as dishwashers or refrigerators, come with a yellow Energy Guide card that shows the estimated kWh per year, so you will not need to do calculations for the large appliances. For smaller appliances, calculate it yourself: A label on the appliance will show watts (W) used. Convert this to kilowatts (kW) by dividing by 1,000. Multiply the kilowatts by the number of hours used in a year to get kilowatt-hours (kWh) per year. Round off to the nearest whole kWh.

Example: A toaster oven uses 1,200 Watts and you use it for 3 minutes every day:

1,200 W/1000 = 1.2 kW

(3 minutes/day x 365 days/year)/60 minutes/hour = 18.25 hours/year

1.2 kW x 18.25 hours = 22 kWh per year

After you have calculated the kWh per year for the smaller appliances, fill in the last column of Table 9 with the appliances in the correct order.

TABLE 10: Data for Calculating Electricity Use

Appliance	Wattage	Time used per year	Electricity use per year, rounded off to nearest kWh
Clothes dryer			Energy Guide: **684 kWh per year**
Clothes washer	–	–	Energy Guide: **196 kWh per year** (based on 8 loads a week)
Coffee maker (2-cup)	700	10 minutes, 365 days a year	
Dishwasher	–	–	Energy Guide: **270 kWh per year** (based on 4 loads a week)
Hair dryer	1875	1 hour a week, 52 weeks a year	
iPhone 6	10.5 Wh (watt-hour) per charge	365 charges per year	
Lamp with a 60-watt incandescent bulb	60	3 hours a day, 365 days a year	
Lamp with a 13-watt compact fluorescent bulb	13	3 hours a day, 365 days a year	
Laptop computer	60	3.25 hours a day, 365 days a year	
Microwave	800	10 minutes, 365 days a year	
Refrigerator with side-mounted freezer, and through-the-door ice	–	–	Energy Guide: **630 kWh per year**
Refrigerator with top-mounted freezer	–	–	Energy Guide: **383 kWh per year**
Television, 65-inch plasma	–	–	Energy Guide: **346 kWh per year** (based on 5 hours of use a day)
Television, 32-inch LED	–	–	Energy Guide: **89 kWh per year** (based on 5 hours of use a day)
Vacuum cleaner	1,440	1 hour a week, 52 weeks a year	
Video game system with television	video game: 20 W LCD television: 150 W	3 hours a day, 300 days a year	
Video game on desktop computer	computer CPU: 68 W Monitor: 84 W	3 hours a day, 300 days a year	
Water heater (40 gallon)	–	–	Energy Guide: **4,773 kWh per year**

PART D: Benefits and Costs of Replacing Old Refrigerator

Imagine that your refrigerator is more than 20 years old and you want to replace it.

TABLE 11: Refrigerator Energy Use and Cost Per Year Comparison

		Features	Cost	Average energy use per year according to Energy Guide label	Average cost per year according to Energy Guide label
	Old Refrigerator From 1990-1992	Top freezer, 19-21 cubic feet	N/A	1,285 kWh	$142.64
	Refrigerator B Frigidaire FFTR1814QB (2015 model)	Top freezer, 18 cubic feet	$521	404 kWh	$48

Source: www.energystar.gov/index.cfm?fuseaction=refrig.calculator and Home Depot website.

1. How much money would you save each year on your electric bill with the new refrigerator?
2. How many years until your savings paid for the cost of the new refrigerator? This time period is called the "payback period," because at the end of it, you'll have been "paid back" for the money you spent on the new refrigerator.
3. What would the yearly reduction in emissions of sulfur dioxide be, assuming 0.002 lbs of sulfur dioxide per kWh?
4. What would the reduction in emissions of nitrogen oxides be, assuming 0.0008 lbs per kWh?
5. Imagine you have decided to keep the old fridge in the garage to hold drinks and snacks. How much would it cost each year to run both the old fridge and the new one?
6. How much sulfur dioxide emissions would result from generating the electricity need to run both refrigerators each year?
7. How much nitrogen oxide emissions would result from generating the electricity need to run both refrigerators each year?
8. After purchasing your new refrigerator, would you keep the old refrigerator in the garage for drinks and snacks or get rid of it? Explain your reasoning.

Contact us

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