



## SUMMARY

Working collaboratively, students will synthesize their knowledge of air quality and apply it to a research, stewardship, or education project. Students' interests and passions will guide the choice of projects, which can be carried out by the entire class or by small groups. This activity guide compiles resources and a brief description of each idea, but details will be left to the students so that they can design and take ownership of the project. Ideally, the class will have completed at least one other activity in the *It's Our Air!* curriculum before starting the Community Air Quality Project.

## ESSENTIAL QUESTIONS

- Why is it important for our class and the community to know about air quality and air pollution?
- How can my classmates and I make a positive difference in air quality?
- How can our class involve the school and/or community in a project about air quality?

## TIME NEEDED

Varies, depending on project.

North Carolina

## ESSENTIAL STANDARDS

FOR EARTH/ENVIRONMENTAL SCIENCE

- EEn.2.8 Evaluate human behaviors in terms of how likely they are to ensure the ability to live sustainably on Earth.
- Other possible standards as well, depending on project

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## MAKING CONNECTIONS

This activity is all about making connections. Students will take what they have learned in the classroom and connect it to a real-world issue or situation outside the classroom to make a positive difference in air quality.

In so doing, they will synthesize their new-found knowledge and apply it in a creative way, mastering material and going beyond memorizing facts for a test. Furthermore, when students pursue projects that relate to their own interests and motivations, they are more likely to be engaged, and students who are engaged are more likely to learn and remember.

In choosing, designing and carrying out the project, students will work cooperatively in teams, an important skill for most work environments.

## BACKGROUND

In this activity, encourage your students to follow their passions to choose a group project to carry out. Depending on the size of the class, the time available, and the interests of the class, the entire class could work on one project, or individual groups could pursue different projects.

The idea is for students to apply some of their new-found knowledge in a creative way to improve air quality – through educating a wider audience, implementing a change on campus, or making data-supported recommendations to school administrators.

The sky's the limit, but here are some ideas to get you started. (Websites and other resources for each of these are listed in the activity section.)

### Transportation

- Reduce vehicle emissions at school by encouraging teachers, staff, and students to reduce idling time, maintain cars and buses properly, and drive green.
- Build your own electric vehicle by participating in the EV challenge.

### Outreach and Education

- Create a school-wide or community-wide campaign about air pollution and how to reduce air pollution emissions. This could take the form of brochures, posters, presentations, website, air quality fair, etc.
- Design and create an outdoor education space on campus for air quality. Examples: lichen garden, ozone garden.

### Campus Energy Audit

Carry out a school-wide or classroom energy audit and make recommendations to reduce air pollution emissions.

### Cost-Benefit Analysis

Perform a cost-benefit analysis for making improvements on campus related to energy efficiency. Present results to school administrators or the school board.

### Engineering

- Build a wind turbine.
- Analyze the potential for wind energy on campus, including a cost analysis.
- Analyze the potential for solar energy on campus, including a cost analysis.

### Public Debate

- Debate Clean Air Act legislation with respect to some actual court cases and suggest ways in which legislation could be improved.
- Create a court case that has regulatory community on one side and environmental and/or industrial community on the other. Argue the pros/cons about why regulation should remain in place, be strengthened or be relaxed. Pick a pollutant and/or an industry not currently in North Carolina like oil refineries.

### Evaluation

The class can evaluate their project(s) using the Community Air Quality Project Evaluation, which can be submitted to the Division of Air Quality if desired, for assessment. The best of the projects will be formally recognized by the Division of Air Quality and may be shared on the *It's Our Air* website. For more information, see the Assessment section.



## MATERIALS

Varies, depending on project.

## WARMUP

In a class discussion, ask students what they've learned about air quality and air pollution. What ideas for preventing air pollution are most exciting to the class? What ideas have the most potential for making a real difference? Ask students to brainstorm a project the class could do together.

Depending on how much time you have available, you may wish to have students spend some time investigating some of the project ideas to gain a better idea of what projects they are most interested in and which ones are most feasible.

As a class (or in small groups), come to a consensus on a project to pursue.

Ideas, suggestions, and resources for different projects are presented in the Activity section. The information is designed to inspire students, while allowing freedom for them to come up with their own ideas. In any case, students don't need

to follow these suggestions to the letter. If they become motivated to follow different paths, try to find ways to encourage them to do so.

If the entire class is going to cooperate on one project, it may be difficult to come to a decision about what project to pursue. There are many modern group-planning tools to help a large group of people make a choice together. If you're already familiar with a process that works well, feel free to use that. If you need a suggestion, read on.

### One Method for Group Decision-Making

One way is to break into small groups and have each group discuss various project ideas and generate a list of 10 possible projects. List all of these on the board and discuss pros and cons as a class. Next have each student write on a piece of paper whichever five projects they are most interested in. Tally these results and then highlight the five projects that got the most votes. Again, as a class, discuss the merits of these five projects. Have each student write on a piece of a paper three projects they are most interested in. Tally the results, and the project with the most votes wins.

## Teacher Tips

If your class has not done another activity from *It's Our Air* before this one, consider showing the video from activity 1-4, "Criteria Pollutants and a Closer Look at Ozone." It gives a good overview of air pollution in general and the six criteria or common air pollutants in particular, including sources and health effects.

Set the stage for success by allowing your students to pick a project they are enthusiastic about, and yet will not be so challenging that the chances for success are slim.

If you're pressed for time, you can turn this into a one-period in-class activity by having a class discussion about air quality and air pollution, then asking students to write an essay about what they could do as individuals or as a school to have a positive impact on air quality.

– Mark Townley



## THE ACTIVITY

No matter what project you choose to carry out, follow these steps, assigning deadlines and people responsible for each step:

- Evaluate project ideas as a class.
- Choose a project.
- Assign roles.
- Collect information related to project.
- Make a plan, including a timeline and deliverables, which should be approved by the teacher.
- Carry out the plan.
- Report and evaluate the plan using the Community Air Quality Project Evaluation (see Assessment Section for more information).

### Project Ideas

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### Transportation Ideas

#### Reduce Vehicle Emissions

Transportation is one of the biggest sources of air pollution emissions in North Carolina. Students, faculty, and staff may get to and from school via school buses, city buses, private cars, and by foot or bike.

How can you encourage the school community to reduce emissions due to driving? Consider a public awareness campaign or a school-wide contest. Keep in mind that there are many different audiences and stakeholders: bus drivers, students, parents, and the school system's maintenance and purchasing department.

Bus and car emissions can be reduced through a number of strategies:

- Technology (newer school buses pollute much less than older ones)
- Green driving habits (avoiding jackrabbit starts, reducing idle time, avoiding a drive-through, using cruise control, not speeding, and more)

- Proper maintenance (maintaining proper tire pressure, changing oil and air filters regularly, and more)
- Reducing driving by walking or biking to school, carpooling, or taking the bus

More information about saving energy and improving air quality through transportation strategies, including resources specific to North Carolina from the Campaign for Clean Air:

[www.campaignforcleanair.org](http://www.campaignforcleanair.org) and  
[www.centerfortheenvironment.org](http://www.centerfortheenvironment.org)

More information about efficient driving habits, including downloadable posters, from the North Carolina Department of Transportation:

[www.ncdot.gov/travel/drivegreen/](http://www.ncdot.gov/travel/drivegreen/)

Clean School Bus USA is a project designed to reduce the number of buses using diesel fuel and/or reduce the emissions from diesel school buses to protect kids' health and reduce air pollution. Students might want to do a survey to find out what kinds of buses their school system uses and how much they pollute. Grants are available to help individual school systems reduce the pollution emitted by their school buses. See:

[www.epa.gov/cleanschoolbus/](http://www.epa.gov/cleanschoolbus/)

More information about idle reduction from the U.S. Department of Energy, including downloadable posters, etc.:

[www1.eere.energy.gov/cleancities/toolbox/idlebox.html](http://www1.eere.energy.gov/cleancities/toolbox/idlebox.html)

More information about idle reduction from the North Carolina Division of Air Quality:

<http://deq.nc.gov/about/divisions/air-quality/motor-vehicles-air-quality/idle-reduction>

<http://deq.nc.gov/about/divisions/air-quality/motor-vehicles-air-quality/idle-reduction/faqs>

<http://deq.nc.gov/about/divisions/air-quality/motor-vehicles-air-quality/idle-reduction/turn-off-your-engine-campaign>

#### EV (Electric Vehicle) Challenge

Teams of high school students work together to design and build electric vehicles that will compete against EV's from other schools. There are three classes of vehicles, ranging from full-size cars/trucks to small, single-person vehicles.

More information is available here:

[www.evchallengekids.org/schools/](http://www.evchallengekids.org/schools/)



### Outreach and Education Ideas

Here's an opportunity to share what you've learned about air quality with others. You'll find that teaching is a great way to deepen your own understanding, whether it's through an air quality campaign or creating an educational garden on campus.

For more resources and ideas about environmental education projects, see:

[www.eenorthcarolina.org/about-us--what-we-do.html](http://www.eenorthcarolina.org/about-us--what-we-do.html).

### Air Quality Campaign

Take a leadership role in your school and community to encourage others to work together to prevent air pollution to improve the health of the community. Design and carry out a marketing campaign for the entire school community about ways to improve air quality. (Note: If students are interested in creating a campaign about the history and success of the Clean Air Act, see the Extensions section of Activity 3-4: The Clean Air Act.)

Educate about air quality, including these topics:

- The connection between energy and air quality
- Health effects of air pollution
- Ways to prevent air pollution at home, at school, and on the move

Get the message out:

- Design and distribute posters, brochures, and presentations.
- Visit classrooms at your school and/or the local elementary school to educate students.
- Produce a PSA (public service announcement) video and/or audio spot to air on school stations and/or community stations.
- Email information to parents.
- Create petitions/pledges for students to commit to saving energy at home.
- Use social media to encourage students to post pictures of themselves taking action to improve air quality.
- Organize projects to bring people together to learn and reduce air pollution.
- Offer participants the opportunity to win prizes.

Measure results:

- Conduct a pre-evaluation and post-evaluation to assess how well your campaign educated people, changed behavior, and prevented air pollution.
- You can also use the pre-evaluation to guide your campaign by using it to identify misconceptions and/or energy-wasting behaviors that are particularly common.

### Air Quality Garden

Design and build an on-campus garden to educate students, teachers, and neighbors about some of the ways that plants and animals depend on clean air. Consider collaborating with another group on campus, such as an agriculture or biology class or club.

Plant some species that are particularly sensitive to ozone and some that are not. Monitor all the plants for the damaging effects of ozone. For more information on creating an ozone garden, see:

[www.handsontheland.org/data/documents/ozone\\_monitoring\\_guide\\_2011.pdf](http://www.handsontheland.org/data/documents/ozone_monitoring_guide_2011.pdf)

### Campus Energy Audit

This is not a one-size-fits-all project; there are many ways to approach it. Here are some ideas:

- Complete an energy audit of the entire school campus (suggested procedure below).
- Do an energy audit of your classroom and multiply the results by the number of classrooms in the school.
- Recruit other classrooms to do energy audits as well. The Cool School Challenge, a program of the Puget Sound Clean Air Agency, has instructions for a classroom energy audit that focuses specifically on carbon dioxide emissions. See: [www.coolschoolchallenge.org](http://www.coolschoolchallenge.org) and look for the classroom audit toolkit under "Materials."
- Enlist the help of outside organizations, such as the Catawba Center for the Environment's N.C. Green School's Program. See: <http://catawba.edu/news-events/news/college-news/catawbas-center-environment-assumes-leadership-nc-green-schools-program> and [www.campaignforcleanair.org](http://www.campaignforcleanair.org)
- Consider doing an energy audit each year and comparing results to those from previous years.

If you would like to do an energy audit of your whole school, here are some tips and ideas to help get you started:

Obtaining energy bills: Call the central school system office and ask to speak to Accounts Payable to see if you can get copies of the school's energy bills, which may include electricity, natural gas, oil, and/or other fuels.



## Campus Energy Audit

Equipment (furnace, AC, lights, ovens, shop equipment, etc.)	Location (hallways, cafeteria, shop, basement, playing fields, etc.)	Fuel Used (electricity, gas, coal, etc.)	Under Whose Control (central office, custodians, teachers, students, etc.)	Notes

## Campus Energy Audit (continued)

Getting the lay of the land: Ask your school's Director of Facilities Management to give the class a tour of energy-using equipment on campus. Fill out a chart during the tour. See the chart above for an example of what that might look like.

Questions to consider:

- What are the different types of energy used at your school? Electricity? Natural gas? Oil? Coal? Other?
- What electric utility company supplies electricity to your school and what is the mix of fuel used by that utility? (See the EPA Clean Energy's Power Profiler at: [www.epa.gov/energy/power-profiler](http://www.epa.gov/energy/power-profiler) or call your electric utility company.)
- Given the mix of fuel at the electric utility and the amount of electricity your school uses in a year, calculate the emissions of sulfur dioxide and nitrogen oxide produced as a result of electricity use at your school per year.
- If your school also uses natural gas, oil, or coal in addition to electricity, calculate the emissions from that energy use as well (see the handout titled "Energy, Electricity, Emissions, and Units").
- What are some of the school's biggest energy users? Heating? Cooling? Cooking? Indoor lights? Outdoor lights? Other?
- What are the areas of biggest potential energy and/or cost savings and why do you think so?
- Are there barriers to realizing those energy savings and if so, what are they?
- What would be some easy ways to save energy that could be implemented immediately?
- Prepare a report for the site-based decision making committee, PTA, or school board summarizing the results of the project and making recommendations for action.

## Cost-Benefit Analysis

Choose an energy-efficiency measure for your classroom or school and calculate the possible savings, in money, energy and/or emissions. Some examples:

- Count the number of lights (or desktop computers) in the main building. Are some left on overnight? If so how many? Find out how much energy each light fixture (or an average desktop computer) uses and calculate how much energy could be saved by reducing the number left on overnight.
- If the energy bills separate out some uses, such as heating/cooling or the football field lights, use that specific data to help define a project to analyze.
- If you already know how much energy your heating/cooling equipment uses, you could call a heating/cooling contractor to get an estimate for how much energy a state-of-the-art system would use for a school your size. If they can give you an estimate for the cost of the new equipment, even better!

## Engineering Ideas

For any of the following ideas, consider collaborating with engineering classes, enlisting the help of an engineering parent, or reaching out to industry partners and/or regional engineers with the Division of Air Quality.

## Evaluate Wind Energy Potential on Campus

Most of North Carolina does not have winds that are strong and regular enough to make wind-generated power economically viable. However, some areas along the coast (particularly the Outer Banks) and on mountain ridge tops are viable. If your school is in or near such an area, analyze the wind potential on campus.



### Evaluate Wind Energy Potential on Campus (continued)

#### Resources:

Map of wind turbines in North Carolina:  
<http://wind.appstate.edu/turbine-map>

Wind resources map of North Carolina:  
<http://wind.appstate.edu/resources/wind-maps-and-resource-assessment>

Plotting a wind rose using Excel:  
[www.enviroware.com/plot-a-wind-rose-in-excel/](http://www.enviroware.com/plot-a-wind-rose-in-excel/)

Planning a small wind electric system:  
<http://energy.gov/energysaver/small-wind-electric-systems-and>  
[http://en.openei.org/wiki/Small\\_Wind\\_Guidebook](http://en.openei.org/wiki/Small_Wind_Guidebook)

### Build a Wind Turbine

Team up with a shop class to design and build a working wind turbine. For ideas, see:

<http://kidwind.org>  
[www1.eere.energy.gov/education/pdfs/wind\\_basicpvc-windturbine.pdf](http://www1.eere.energy.gov/education/pdfs/wind_basicpvc-windturbine.pdf)  
<http://energy.gov/eere/education/education-homepage>

### Evaluate Solar Energy Potential on Campus

Does your campus have space that could be devoted to solar photovoltaic (PV) panels – roofs, on or next to playing fields, parking lots, etc.? Use a Google Earth map of campus and your knowledge of the angle of the sun at different times of year to make sure the chosen locations would receive enough sun. Do a cost-benefit analysis of using solar energy to power some of the school's energy needs.

#### Resources:

Information about many aspects of solar energy in North Carolina:  
<https://nccleantech.ncsu.edu>

#### Solar potential maps:

<http://energy.gov/maps/solar-energy-potential>

A Google tool to analyze solar potential of your roof:  
[www.google.com/get/sunroof#p=0](http://www.google.com/get/sunroof#p=0)

To determine optimal angle for solar panels on your campus:  
[www.solarpaneltilt.com](http://www.solarpaneltilt.com) and  
<http://solardat.uoregon.edu/SunChartProgram.html>

### Public Debate Ideas

Have a public event, perhaps in cooperation with the PTA or PTSA, and invite parents, faculty, students, and staff.

Consider bringing an outside speaker to school to generate interest and awareness about air pollution and the role of regulation in keeping the air clean and the community healthy.

Collaborate with the Debate Team to stage a debate, mock court case, or public hearing. Ideas:

- Students could research some actual court cases involving the Clean Air Act and argue the same topics.
- Pick a pollutant and an industry not currently in North Carolina, like oil refineries. Imagine this industry was coming to your community. Research the air pollution consequences of such an industry, as well as the potential for creating jobs. Assign student groups to represent different stakeholders, such as industry, regulators, environmentalists, chamber of commerce, and community members, and have the different groups present their arguments for or against issuing an air permit for this industry and/or relaxing air quality standards for the new industry.



## WRAP UP AND ACTION

Depending on the project, the class may wish to share their project with a wider audience – by writing an editorial or blog post or article for the school or community newspaper; making a presentation to the PTA or school board; or interacting with another group or class on campus to carry their project further.

As a class, consider whether there are aspects of the project that should be archived so that future classes can build on the work that's been done.

## ASSESSMENT

### HAVE STUDENTS:

- Evaluate the effectiveness of their project and make suggestions for how the project could have been improved.
- Write a letter to next year's class with tips for choosing a project and carrying it out successfully.
- The class can use the Community Air Quality Project Evaluation as a way of evaluating the success of their project. This is available through a link on the activity page for this activity on the *It's Our Air* website. If desired, the class can submit the evaluation form and the Division of Air Quality will assess the project for excellence. The best of the projects will be formally recognized by the Division of Air Quality, and may be summarized on the *It's Our Air* website.





# 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.

$$J = (\text{kg} \times \text{m}^2)/\text{s}^2$$

**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.

$$W = \text{J}/\text{s}$$

**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.



## Research and Action: Community Air Quality Project

Energy Review  
Page 2

Energy, Electricity, Emissions, and Units (continued)

### 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](http://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](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: