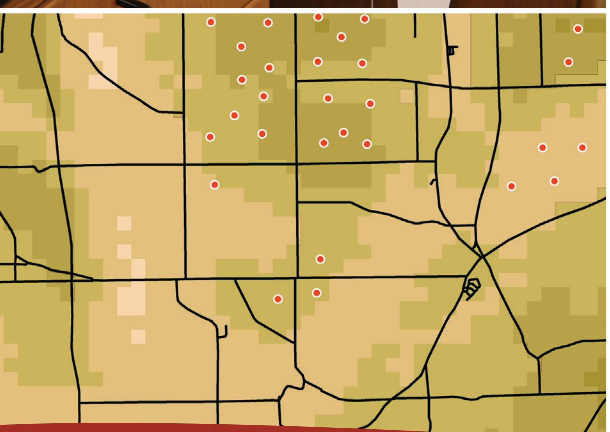
WindWise Education

Transforming the Energy of Wind into Powerful Minds



A Curriculum for Grades 6–12

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2nd edition

windwise education

www.WindWiseEducation.org

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New York State
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V2.0

UNDERSTANDING ELECTRIC POWER GENERATION

LESSON 2

KEY CONCEPT

Students learn about the environmental, economic and social trade-offs of electrical power generation technologies.

TIME REQUIRED

2 class periods

GRADES

6–8
9–12

SUBJECTS

Environmental Science
Physical Science
Technology

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BACKGROUND

We use nine primary sources of energy to generate our electric power needs in the United States. Electricity is considered an energy carrier because it does not exist in nature in a usable form. Projections are that our electricity demand in the United States will increase 30 percent by 2040. In order to meet this increased demand, additional generation technologies are needed. The question becomes, do we build additional fossil fuel and nuclear power plants or do we use renewable technologies such as wind and solar?

OBJECTIVES

At the end of the lesson, students will:

- understand the concept of energy carriers
- be able to explain why electricity is an energy carrier and not a primary energy source
- be able to explain how electricity is generated and transmitted
- be able to list the primary sources of energy that are used for electric power generation
- be able to compare and contrast advantages and disadvantages of coal vs. wind electric power generation
- understand the advantages and disadvantages of the primary sources of energy used for electric power generation

METHOD

Students explore electric power generation and consider the advantages and disadvantages of different generation technologies through a demonstration, PowerPoint, class discussion, reading passage and worksheets.

MATERIALS

- ❑ "Electric Power Generation" PowerPoint presentation (http://kwind.me/r2b)
- ❑ Student Reading Passages and Student Worksheets*

*included with this activity

ENERGY LOSSES

Every conversion or transfer of energy results in a "loss" of energy, but the amount lost varies with the specific conversion or transfer.

GETTING READY

- Make copies of the Student Reading Passages and Student Worksheets
- Download the Electric Power Generation PowerPoint presentation (http://kwind.me/r2b)
- Review the lesson, student sheets, and PowerPoint to become familiar with the concepts

PART 1: ELECTRIC POWER GENERATION

Step 1: Introduction and energy carriers
Ask students to focus on the important role electricity plays in their everyday lives. Ask them what items they used during the last week that were powered by electricity. Ask them to consider how different their lives would be if they didn't have electricity. How would their lives change? Other questions for students to consider:

- Have any students ever experienced a situation in which their house lost electrical power for a significant amount of time? Ask them to discuss their experiences.
- Where do we get electricity?
- How is electricity produced in a power plant?
- Does all of their electricity come from their local power plant?

Don't worry about whether or not students can answer these questions correctly. The purpose of these questions is to determine students' preconceived ideas.The concepts will be covered in the "Electric Power Generation" PowerPoint presentation that you will show students later in this lesson.

Show students only the first four slides of the presentation. Make sure you go over the talking points in the notes section of the presentation.

Step 2: Electric Connections activity
This activity courtesy of NEED Project. www.need.org

Give each student a copy of Electric Connections instructions.

Ask each student to rank the nine sources of energy in order of their contribution to US electric power generation. Students should use the second column to list their individual rankings in the second column.

Organize students into groups of 3–5. Ask them to review each of their rankings and share with the group the reasons for their ranking. Next, students need to come to consensus on a group ranking and then enter this in the third column.

When they are finished, give each student a copy of the US Electric Power Generation Sources sheet. Tell students to transfer their individual and group rankings to the appropriate columns (columns 4 and 6).

Tell students to read the information next to each source and record the actual ranking of each source in the actual rank column. They will use the percentage of each source's contribution to determine the actual ranking.

Actual ranking

- Biomass–7
- Coal–1
- Geothermal–8
- Hydropower–4
- Natural Gas–2
- Petroleum–6
- Solar–9
- Uranium–3
- Wind–5

Tell students to calculate their individual and group error points and list them in the fifth and seventh columns. Next, have students go over the nine sources of energy and designate each source as nonrewable or renewable.

Nonrewable

- Coal (42%)
- Natural Gas (24.8%)
- Petroleum (.7%)
- Uranium (20%)

Renewable

- Biomass (.7%)
- Geothermal (.4%)
- Hydropower (8.1%)
- Solar (.1%)
- Wind (3%)

Ask students to add up the percentages to determine how much of our electricity comes from renewable (12.3 percent) and nonrenewable (87.5 percent) sources. Note: These two numbers do not add up to 100 percent because each source has been rounded off to nearest hundredth of a percent and the solar percentage is actually less than one percent.

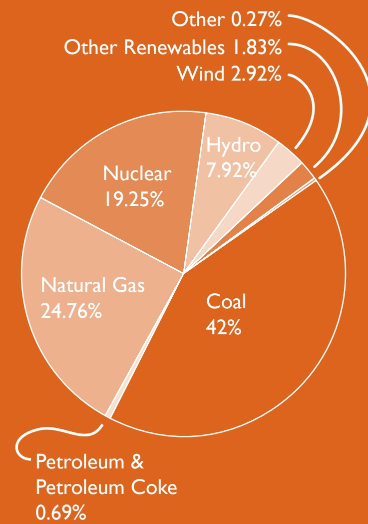
Hold a class discussion about why students think so much of our electricity is generated by nonrewable sources and so little is generated from renewable sources.

Answer: There is no one answer to this question as many factors are involved. However, one of the major factors is the economics of electric power generation. While some sources are actually cheaper than coal (hydropower, wind, solar, etc.), there are disadvantages with each of these sources (availability, reliability, etc.). This concept is explored in Part 3 of this lesson.

Step 3: Electric power generation and distribution

Show students the remainder of the "Electric Power Generation" PowerPoint presentation (slides 5–23). These slides deal with the generation, transmission, and distribution of electricity. Talking points for each slide are located in the Notes section.

US ELECTRICITY SOURCES



Data 2011, from the Energy Information Administration

Keep in mind the this chart is showing sources of energy used to generate electricity. It does not contain sources for transportation or heating.

RENEWABLE ENERGY

One common classification system for energy is to label energy either renewable or nonrenewable. These terms relate to how energy is used by human society rather than being fundamental to energy itself. Non-renewable energy is generally extracted from natural resources such as fossil fuels (coal, oil and natural gas), while renewable energy is taken from natural processes as they occur (solar energy, wind energy and hydroelectric power). When energy is released from coal to create electricity, the stock of coal is reduced; hence it is non-renewable. However, energy used from the wind to turn a turbine is not consumed in the same way. Using wind energy does not make the future less windy!

PART 2: CHOOSING FUTURE ELECTRIC POWER GENERATING TECHNOLOGIES

Step 1: Introduction

Ask students if they have any concerns about the US using coal to generate almost 46 percent of our electricity. Possible answers include:

- Coal is not a sustainable energy source. Its quantity is finite.
- Coal-fired power plants are a leading source of toxic mercury in our lakes and streams.
- Coal-fired power plants are a major contributor to acid rain.
- When coal is burned, harmful air pollutants are released into the air, such as sulfur dioxide, nitrogen oxides, and particulates.
- Coal-fired power plants are a major contributor to climate change (global warming) due to carbon dioxide emissions.
- Lives are lost in coal mining.
- Coal extraction has a serious impact on the land, such as destroyed mountain-tops and landscapes.
- This energy source has an impact on public health—24,000 premature deaths per year according to the American Lung Association.

Step 2: The economic, environmental, public heath and safety comparisons of coal and wind

Ask students to read the activity reading passage, "Comparisons of Coal and Wind: Economic, Environmental, Public Health and Safety" (page 60).

Step 3: Exploring the tradeoffs of electric generating technologies

After the students read the passage pose some questions:

- Why do we continue to rely on coal to generate so much of our electricity, considering the environmental and health concerns associated with its use?
- Can students think of any advantages of using coal?
- Are there any disadvantages of the other sources (nuclear, wind, solar, hydropower, etc.)?

The United States Department of Energy projects that our demand for electricity will increase 30 percent by 2040. We will need to increase our generation and must decide on what kind of technologies we want to develop to meet this future demand.

There is no "perfect" energy source for generating electricity. All technologies have economic, environmental, and social advantages and disadvantages.

Renewable technologies such wind and solar rely on “free” resources and don’t produce harmful greenhouse gases, but are not always available when needed and sometimes require significant amounts of land.

Technologies such as coal and nuclear reliably produce electricity in large quantities but result in significant greenhouse gasses emissions (in the case of coal or natural gas) or long-term toxic waste considerations (in the case of nuclear).

Recognizing these tradeoffs helps students understand why there is so much debate about which electricity generating technologies we should promote in the future.

Go over the information in the chart on page 63 with students. The data in this chart is provided by the Electric Power Research Institute (EPRI), an independent, non-profit company performing research, development and demonstration in the electricity sector for the benefit of the public.

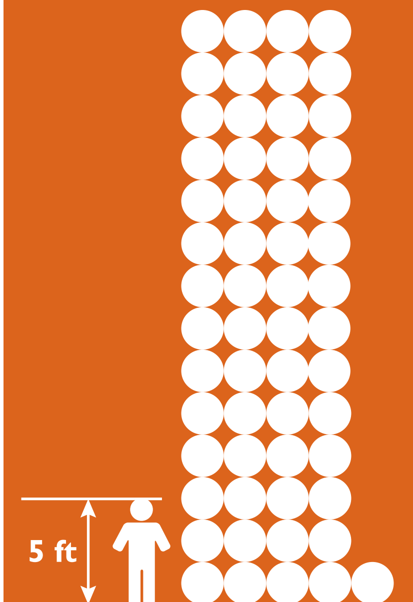
Spend time with students going over the chart to make sure they understand the rankings. It may help students to understand the rankings if they know how many of each type of electrical power generating technologies would be required to generate an equal amount of electricity. The chart below compares the number of each technology needed to provide the annual electrical energy requirements for a large city such as Chicago (approximately 1 million homes).

TECHNOLOGY	NUMBER
Nuclear	1 plant
Coal	2 plants
Natural Gas	3 plants
Biomass	20 plants
Geothermal	30 plants
Wind	2000 turbines
Solar Photovoltaic	1.6 million PV arrays

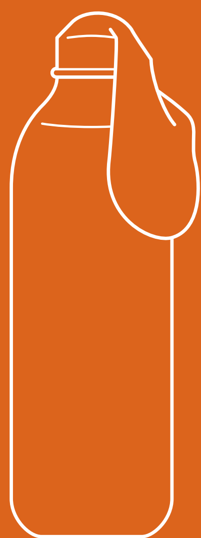
For example, students may not understand why wind receives a "1" (high impact) for land use and nuclear receives a "4" (low impact). However, understanding that it would require much more land to site 2000 wind turbines than it would to construct one nuclear power plant puts the rankings in proper perspective.

Step 4: Choosing future electricity generating technologies activity
After reviewing information in the chart with the students, have them complete the Choosing Future Electricity Generating Technologies worksheet on page 65.

This activity is a values exercise; there are no right or wrong answers for this activity. It is important for students to justify their rankings based on what they think (economics, environment, other, etc.) are the most important considerations in meeting our future electrical power needs. For example, if they rank nuclear as their first choice, they should be able to justify their choice based upon their own values and priorities. A student who thinks that we face major social problems by relying on imported petroleum and environmental issues associated with global warming might rank nuclear power as their first choice because it relies on fuel that is readily available in the US and nuclear power plants don't contribute to climate change due to low CO_2 emissions.



Each day the average American is responsible for the production 57 balloons of CO_2 (large 2 ft wide balloons) through transportation, electricity usage and other lifestyle choices.



Place baking soda in the balloon and stretch it over the bottle neck.

Step 5: Class discussion
Hold a class discussion and have students explain the reasoning behind their rankings. This could be done in small groups or as a whole class discussion.

Stress to students prior to their discussion that there are no right or wrong answers and that the purpose of this activity is to generate discussion and build on each other's knowledge about the advantages and disadvantages of the different electrical power generating technologies.

Be prepared to have students debate their choices as this chart oversimplifies the considerations that might arise. For example, if the student states that nuclear power plants emit no CO_2, another student may counter with the fact that while this is true, fossil fuels, especially oil in the form of gasoline and diesel, are essential to every stage of the nuclear cycle, and CO_2 is given off whenever these are used. Both facts are correct. The ranking in the chart only deals with CO_2 emissions from the nuclear power plant, not the production of nuclear fuel.

EXTENSION

Carbon dioxide demonstration
The bubbling, fizzing chemical reaction between vinegar and baking soada is a standard science experiment. This variation allows you to collect the gas, carbon dioxide, produced in the reaction, as a demonstration of the greenhouse gas emissions of fossil fuel power plants.

Materials:
- 1 glass or plastic bottle between 8 and 16 ounces in size
- Balloon
- Funnel
- 4–6ounces of vinegar
- 1 teaspoon of baking soda

Directions
- Put vinegar into the bottle.
- Pull the open end of the balloon over the bottom of the funnel.
- Pour the baking soda into the funnel and shake it down into the balloon. If the baking soda gets stuck in the neck of the balloon, use a pencil to push it into the balloon.
- Connect the open end of the balloon to the top of the bottle. Keep the balloon hanging down to one side so no baking soda gets into the bottle. You now have a closed system.
- Lift the balloon straight up and shake to mix the two chemicals.
- When the reaction is done, hold the bottle and twist the balloon several times to seal the base of the balloon.
- Pull on the base of the balloon to remove it from the bottle.
- Tie the end of the balloon to seal the gas in.

Discussion

Use this demonstration to help students visualize how much carbon dioxide Americans generate, as explained in the following discussion (Catherine Zandonella).

It's embarrassing to consider how much carbon dioxide (CO_2) we generate. Our cars, homes and lawnmowers spew out this heat-trapping gas on a daily basis. But since carbon dioxide is invisible, we rarely recognize our individual contributions to greenhouse gas emissions.

It would be very helpful if we could inject a dye into CO_2 that made it visible to the human eye. Our cars could be rigged to spew out a putrid brown or a sickly yellow. Just seeing the CO_2 might convince many people to hop on their bikes to do their errands around town. Since coloring CO_2 is not an option at the moment, you have to use your imagination.

The average American's CO_2 emissions are usually tabulated in terms of pounds of CO_2. You are probably familiar with buying your fruits and veggies by the pound. A pound of apples is about three medium-size ones. So how big is a pound of CO_2? It helps to think of CO_2 as gas trapped inside a balloon. Filling a balloon with one pound of CO_2 would swell the balloon to about the size of one of those large rubber exercise balls. The balloon would be about two and a half feet across. Each day the average American fills up about 57 of these balloons through his use of electricity, gasoline, etc.

Now imagine all of those balloons rising up every day from 310,000,000 Americans. You can see how—day after day, year after year—they'd fill up the sky. About half of all electricity in the United States is made from burning coal. Coal-fired power plants emit about 2 billion tons of CO_2 annually. Natural gas power plants, which make about one-fifth of the country's electricity, emit 400 million tons. Only about 10 percent of our electricity is made from hydroelectric and other renewable energy sources such as wind or solar, according to the US Energy Information Agency. Of course, your personal electricity-related carbon emissions depend on where your electricity comes from. But consider that, on average, given the typical sources in this country, even a single 75 watt incandescent bulb burning for two hours a day will generate six pounds of carbon dioxide a month. So be sure to turn off the lights off!

VOCABULARY

acid rain – Rainfall made sufficiently acidic by atmospheric pollution that it causes environmental harm, typically to forests and lakes.

carbon dioxide – A naturally occurring gas, a by-product of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the principal greenhouse gas that affects the Earth's radiative balance.

climate change – Any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer).

energy carrier – Also referred to as a secondary source of energy. Energy carriers are primary energy sources of energy that are converted in an energy transformation process to more convenient sources of energy (such as electricity) that can be used directly by society. Examples include electricity, refined fuels (gasoline, propane, heating oil, ethanol, etc.) and hydrogen.

global warming – Increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, that can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, "global warming" often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities.

greenhouse gases – Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases are the major contributor to global warming and climate change.

hydrocarbons – Substances containing only hydrogen and carbon. Fossil fuels are made up of hydrocarbons.

ELECTRIC CONNECTIONS

Game instructions

Today, 41 percent of the nation's energy is used to make electricity. Experts predict that this figure will continue to increase. The US is becoming more dependent on electricity to meet its energy needs as we depend on more technology. To meet the growing demand, many energy sources are used to generate electricity. Some energy sources produce a substantial amount of the electricity we consume, while others produce less than one percent.

Individual instructions

Your task is to rank the nine sources of energy in order of their contribution to US electricity production. Place number one by the source that provides the largest amount of electricity, a number two by the source that provides the second largest, down to a number nine by the one that provides the least amount of electricity. Use critical reasoning skills to determine the order.

Group instructions

Starting at the top of the list, ask members to contribute any knowledge they have about each energy source. Brainstorm by asking group members questions such as:

- Is this source limited to a certain area of the country?
- Are there any problems or limitations associated with this source?
- Have you ever seen a power plant that uses this particular source of energy?

One person in the group should take notes. Once the group has gone through the list, it should divide the nine energy sources into three levels of importance: the top three most significant energy sources, the middle four moderately significant energy sources, and the bottom three least significant energy sources. The group should then rank the ten sources of energy in order of their contribution to US electricity production.

Sources used to generate electricity

SOURCE	YOUR RANK	GROUP RANK
Biomass		
Coal		
Geothermal		
Hydropower		
Natural Gas		
Petroleum		
Solar		
Uranium		
Wind		

This worksheet appears courtesy of The NEED Project. www.need.org

US ELECTRIC POWER GENERATION SOURCES

Sources used to generate electricity

SOURCE	STATISTICS	ACTUAL RANK	YOUR RANK	ERROR POINTS	GROUP RANK	ERROR POINTS
Biomass	In 2011, biomass produced 27.7 billion kilowatt-hours of electricity, 0.7% of the nation's total. Biomass electricity is usually the result of burning wood waste, landfill gas, and solid waste.					
Coal	94% of the nation's coal is consumed by electric utility companies to produce electricity. In 2011, coal produced 1,714.9 billion kilowatt-hours of electricity, which was 42% of the nation's electricity.					
Geothermal	In 2011, geothermal power plants produced 16.7 billion kilowatt-hours of electricity, chiefly from facilities in the western US. Geothermal energy produced 0.4 percent of the nation's electricity.					
Hydropower	7% of US electricity is generated by 2,400 hydro plants nationwide. In 2011, hydroelectric plants produced 323.1 billion kilowatt-hours of electricity. Hydropower is the leading renewable energy source used to provide electricity.					
Natural Gas	In 2011, natural gas produced 930.6 billion kilowatt-hours of electricity, generating 24.8% of the nation's electricity. Approximately one-half of this natural gas is used by gas turbines to provide electricity during peak hours of demand.					

SOURCE	STATISTICS	RANK	YOUR RANK	ERROR POINTS	GROUP RANK	ERROR POINTS
Petroleum	In 2011, petroleum provided 0.7% of US electricity, generating 26.2 billion kilowatt-hours of electric power.					
Solar	In 2011, solar energy provided less than one-tenth of one percent of US electricity, amounting to 1.8 billion kilowatt-hours of electricity. Electricity was generated by solar thermal systems or photovoltaics.					
Uranium	In 2011, 104 nuclear power plants provided the nation with 20 percent of its electrical energy needs. Nuclear energy produced 790.2 billion kilowatt-hours of electricity.					
Wind	In 2011, wind energy produced 119.7 billion kilowatt-hours of electricity. Wind provided 3% of the nation's electricity. Most of the wind-generated electricity is produced in Texas, Iowa, and western states.					
Error points totals						

Error points are the absolute difference between your rankings and those of the EIA's (disregard plus or minus signs).
Data: Energy Information Administration, Annual Energy Report

Scoring:
0–12 Excellent
13–18 Good
19–24 Average
25–30 Fair
31–36 Poor
37–42 Very Poor

This worksheet appears courtesy of The NEED Project. www.need.org

COMPARISONS OF COAL AND WIND: ECONOMIC, ENVIRONMENTAL, PUBLIC HEALTH AND SAFETY

Economics

Comparing the economics of electricity from coal versus from wind can become very complicated since electricity generation has both capital (construction) costs and ongoing (production) costs, and some models may account for other factors as well (fuel, maintenance, transmission, environmental costs, etc.). One of the most cited economic comparisons of different sources of electricity is published by Lazard, an international financial advisory firm.

The Lazard study gives a comparative levelized cost of different sources of electricity in dollars ($) per megawatt-hour (MWh). This study does include existing subsidies and incentives for each source of electricity, but does not factor in environmental costs, potential carbon emission costs, transmission, or other external costs.

According to Lazard, onshore wind energy costs $57–$113 per MWh, while electricity from coal costs $78–$144 per MWh. Without US Federal Tax Incentives, electricity from wind would cost approximately $84–$140 per MWh. Electricity from wind is cost-competitive with coal. Offshore wind energy is not included in the Lazard study, but is more costly.

If environmental costs are considered part of an economic equation, electricity from wind power becomes even more economically preferable compared to coal.

Air quality and public health

Coal—When coal is burned, harmful air pollutants like sulfur dioxide, nitrogen oxides, and particulates are released in to the air. These pollutants cause and aggravate respiratory diseases, damage lung tissue, and can lead to premature death. They can also harm vegetation, trees, crops and water quality. Burning coal is a leading cause of smog, acid rain, climate change, and air toxins such as mercury. In an average year, a typical coal plant generates:

- 10,000 tons of sulfur dioxide (SO_2), which causes acid rain that damages forests, lakes, and buildings, and forms small airborne particles that can penetrate deep into lungs.
- 500 tons of small airborne particles that can cause chronic bronchitis, aggravated asthma, and premature death, as well as haze, obstructing visibility.
- 10,200 tons of nitrogen oxide (NO_x), as much as would be emitted by half a million late-model cars. NO_x leads to formation of ozone (smog) that inflames the lungs, and can damage lung tissue and making people more susceptible to respiratory illness.
- 720 tons of carbon monoxide (CO), which causes headaches and places additional stress on people with heart disease.
- 220 tons of hydrocarbons, volatile organic compounds (VOCs), that form ozone.
- 170 pounds of mercury, a substance of which just .014 teaspoons deposited in a 25-acre lake can make the fish unsafe to eat.
- 225 pounds of arsenic, a substance which will cause cancer in one out of 100 people who drink water containing 50 parts per billion.
- 114 pounds of lead, 4 pounds of cadmium, other toxic heavy metals, and trace amounts of uranium.

Wind: Wind energy does not involve combustion and does not result in the production of carbon dioxide, sulfur dioxide, airborne particles, nitrogen oxide, carbon monoxide, volatile organic compounds, mercury, arsenic, or lead. Consequently, there is no impact on public health.

Climate change (global warming) pollution

Coal: Coal-fired power plants are the primary source of the principal climate change (global warming) pollutant, carbon dioxide.

- Between 1990 and 2003, total US carbon dioxide emissions increased about 18%.
- About 98% of carbon dioxide emissions in the US come from burning fossil fuels.
- There is broad scientific agreement that human activities are causing the temperature of the Earth's atmosphere to rise.
- With only 5% of the world's population, the US emits 22% of the world's greenhouse gases (24 tons per person per year).
- In the last 1,000 years, 20 of the hottest years on record have occurred since 1980. 2005 was the hottest year ever recorded.

Wind: Once again, wind energy does not involve combustion and does not result in the production of carbon dioxide.

Safety

Coal: Underground mining is one of the most hazardous occupations, killing and injuring many in accidents, and causing chronic health problems. The US Department of Labor reports that there were 952 coal-mining fatalities between 1980 and 2010.

Wind: Falling off a roof or wind tower and electrical shock are risks, but they are minimal for properly trained workers. It is difficult to imagine a catastrophic wind accident that would cause 10 or 20 deaths in a single day.

OTHER FACTORS

Solid waste

Coal: Waste created by a typical 500-megawatt coal plant includes more than 125,000 tons of ash and 193,000 tons of sludge from the smokestack scrubber each year. Nationally, more than 75 percent of this waste is disposed of in unlined, unmonitored, onsite landfills and surface impoundments.

Toxic substances in the waste—including arsenic, mercury, chromium, and cadmium—can contaminate drinking water supplies and damage vital human organs and the nervous system. One study found that one out of every 100 children who drink groundwater contaminated with arsenic from coal power plant wastes were at risk of developing cancer. Ecosystems, too, have been damaged—sometimes severely or permanently—by the disposal of coal plant waste.

Wind: No solid waste is generated with wind power.

Water supply and cooling water discharge
Coal: Once the 2.2 billion gallons of water have cycled through the coal-fired power plant, they are released back into the lake, river, or ocean. This water is hotter than the water that receives it. This "thermal pollution" can decrease fertility and increase heart rates in fish. Typically, power plants also add chlorine or other toxic chemicals to their cooling water to decrease algae growth. These chemicals are also discharged back into the environment.

Wind: Water in not involved in the production of wind energy.

Degradation of the landscape
Coal: About 60 percent of US coal is stripped from the Earth in surface mines; the rest comes from underground mines. Surface coal mining may dramatically alter the landscape. Coal companies throughout Appalachia often remove entire mountaintops to expose the coal below. The wastes are generally dumped in valleys and streams.

In West Virginia, more than 300,000 acres of hardwood forests (half the size of Rhode Island) and 1,000 miles of streams have been destroyed by this practice.

Wind: Some people consider the turbines to have an undesirable appearance, especially when there are very tall units and/or large groups of them. The same could be said for coal power plants, but these are concentrated into a smaller number of facilities.

Transportation & storage
Coal: A typical coal plant requires 40 railroad cars to supply 1.4 million tons in a year. That's 14,600 railroad cars a year.

Railroad locomotives, which rely on diesel fuel, emit nearly 1 million tons of nitrogen oxide (NO_x) and 52,000 tons of coarse and small particles in the United States. Coal dust blowing from coal trains contributes particulate matter to the air.

Coal burned by power plants is typically stored onsite in uncovered piles. Dust blown from coal piles irritates the lungs and often settles on nearby houses and yards. Rainfall creates runoff from coal piles. This runoff contains pollutants that can contaminate land and water.

Wind: Wind energy requires no transportation or storage.

ADVANTAGES AND DISADVANTAGES OF ELECTRICITY GENERATING TECHNOLOGIES

Electricity generation technologies all have advantages and disadvantages. Renewable technologies such as wind and solar use “free” resources and don’t produce harmful greenhouse gases, but are not always available when needed and require significant amounts of land. Technologies such as coal and nuclear produce electricity in large quantities reliably, around the clock, but result in significant greenhouse gases (in the case of coal) and long-term waste disposal considerations (in the case of nuclear).

Recognizing these tradeoffs helps everyone understand the considerations that must be taken into account in deciding which energy sources we should be promoting to meet our future electric power needs.

ASSESSMENT OF RELATIVE BENEFIT/ IMPACT	COAL	NATURAL GAS	NUCLEAR	HYDRO	WIND	BIOMASS	GEO-THERMAL	SOLAR PHOTO-VOLTAIC
Construction Cost New plant construction cost for an equivalent amount of generating capacity	**3**	**4**	**0**	**2**	**3**	**2**	**1**	**0**
Electricity cost Projected cost to produce electricity from a new plant over its lifetime	**4**	**4**	**3**	**1**	**2**	**2**	**2**	**0**
Land use Area required to support fuel supply and electricity generation	**2**	**3**	**4**	**2**	**1**	**0**	**3**	**1**
Water requirements Amount of water required to generate equivalent amount of electricity	**0**	**2**	**0**	**2**	**4**	**0**	**2**	**4**

ASSESSMENT OF RELATIVE BENEFIT/ IMPACT	COAL	NATURAL GAS	NUCLEAR	HYDRO	WIND	BIOMASS	GEO-THERMAL	SOLAR PHOTO-VOLTAIC
CO_2 emissions Relative amount of CO_2 emissions per unit of electricity	**0**	**2**	**4**	**4**	**4**	**3**	**3**	**4**
Non-CO_2 emissions Relative amount of harmful air emissions other than CO_2 per unit of electricity	**0**	**2**	**4**	**4**	**4**	**1**	**3**	**4**
Waste Products	**0**	**4**	**2**	**4**	**4**	**1**	**3**	**4**
Availability Ability to generate electricity when needed	**4**	**4**	**4**	**2**	**0**	**4**	**4**	**0**
Flexibility Ability to quickly respond to changes in demand	**2**	**4**	**1**	**4**	**0**	**2**	**3**	**0**

Ranked with 0 meaning highest impact/cost and 4 meaning lowest impact/cost.

CHOOSING FUTURE ELECTRICITY GENERATING TECHNOLOGIES

Based upon your values, rank the energy sources from 1–8, with 1 being your first choice for generating electricity and 8 being your last choice.

ENERGY SOURCE	RANKING	REASON FOR RANKING
Coal		
Natural Gas		
Nuclear		
Hydropower		
Wind		
Biomass		
Geothermal		
Solar		