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Catch the Wind

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Introduction

Near the end of the school year, while trying to get my class settled down, I was unexpectedly confronted by a man in running shorts and a T-shirt who approached me directly, derailing my previous intention of bringing order to the class. He asked if I was "in charge of the weather station on the roof." Figuring there was no way to answer in a way that he would turn and leave, I surrendered the truth and hoped for the best. The school announcements had commenced and some students were broadcasting the weather report and forecast. The class quieted down to hear the "news." "Yes," I replied, "I guess I am." He quickly said his name (Phil something), apologized for not having any business cards and informed me that he worked for a renewable energy company. He said they wanted to put a wind turbine on our campus, they were expecting a fight over the local height restrictions, and that if I would be so kind as to share our wind data with him, they would all be grateful.

Suddenly, I was not so concerned about the students being quiet for the morning announcements. I did not worry that they might run out in the hall and hurt each other. As it turned out, they were sitting at their desks doing their work as usual, and I was thinking, "serendipity."

I briefly told him of my plans to go to Yale to participate in a seminar on Renewable Energy and that his interests dovetailed beautifully with mine — i.e., to write a curriculum unit on renewable energy. It was then that I decided to focus on wind power.

We have a fair amount of wind and sunshine in our region, northern New Mexico. In addition, there is a strong energy industry to the south, national nuclear labs in Los Alamos and Albuquerque, and a governor who supports the utilization of our natural renewable resources — i.e., sun and wind. At our school, a weather-tracking station measures and reports the wind direction and force/speed 24 hours per day. There are also local renewable energy companies near by. One company in particular, Conergy (represented by Phil), approached me about sharing our school data on wind to support their efforts in erecting wind turbines in the area — in particular, on our school, Turquoise Trail Charter School (TTCS) campus.

My first thought upon hearing this proposal was to envision my students gathering and charting the data, building an understanding of their findings and presenting them in a convincing way to someone who cares. In other words, I pictured my students doing research and testifying before a county commission on reasons

Conergy should be granted a variance on the local height restrictions to build a wind turbine. My vision expanded to seeing my students present their case in a more powerful way by speaking to the state legislature next winter.

For this vision to succeed, I need to have a group of students who are interested in and committed to learning about the challenges and benefits of wind energy. They also must have the resources and the leadership to bring their efforts to a rewarding conclusion.

Overview

With the growing body of knowledge supporting the reality of global warming [1], it is more important than ever for citizens to be aware of and understand their responsibility as stewards of their home planet. I don't think there is a grade level that is too young to begin learning about our fragile Earth, and fifth grade is certainly not too young for them to think about their roles in the different communities they live in. Up until now, their experience has taught them to look little beyond their school, neighborhood, and home for their circle of influence — i.e., what influences them and where they may have some influence over others.

Many of my students have parents who came from Mexico — legally and illegally, and their view of the world is focused on just getting by. About 70% of the families in our school area are Hispanic. There are a few Native Americans and Asians (about one to four percent) and about 80% of the students are on free or reduced-cost lunch. Even those parents who were born here have relatives and friends who are concerned enough about their "social" security and legal status to distract, if not impact, their own lives. The kids who grow up in this kind of environment do not grow up with the world's stage being discussed at the dinner table. In a nutshell, my students do not normally have a global perspective included in their world view. Of course, this is not unique to New Mexico. There are communities across the nation where parents from low socio-economic backgrounds are less informed than their children's teachers. Part of our responsibility in teaching and preparing them is to teach them social responsibility. Ironically, and perhaps luckily, these students often spend more time with me than they do with their parents.

One of the themes that I regularly include across the curriculum is "responsibility and citizenship." Each year, our students learn about their community — starting with their home and family and expanding that community each year to include their classroom, their school, their neighborhood, their town, and so on up to their place in the global community. In the fifth grade, we are at the stage where they are finding their place in the greater, global community. They are discovering how they fit in and what is included in their responsibilities regarding learning and citizenship. One of these responsibilities concerns our planet's atmosphere and global warming.

Citizens should do whatever they can to improve the status of their world, including identifying the resources available to them to do so. In New Mexico, this includes abundant sunshine and wind. It is often cited that New Mexico enjoys, on average, 300 sunny days per year [2]. There are no equivalent "charming" statistics concerning the wind. Suffice to say there is quite a bit of wind too — particularly in the eastern part of the state and on the prairies near my school.

It is my intention to help my students learn how using wind energy will help improve conditions around the

world. Wind power is known to emit no carbon emissions other than in the production of wind turbines and that even if we cannot "see" the savings by watching, we "know" it is happening (by reading statistics and studies) and we can feel satisfaction for doing our part [3]. In addition, I hope that other teachers and school leaders will be inspired to good environmental behaviors by seeing how our small group of young citizens has made a difference. If they want to copy our project using this curriculum unit, they can adapt it to suit the age of their students and the natural renewable resources common to their area. If they merely use our spirit and have their own plan, I am equally pleased. In any case, I hope this effort will energize some one or some group to make a difference.

As I suggested, this unit can be taught in any grade. Since I am teaching intermediate elementary, I will address these grades (fourth, fifth, sixth) in particular. In the younger grades, the lessons can be adjusted to include community building (social studies), simple machines (science), counting (math), and writing (language arts). In intermediate grades, the social studies lessons include government, civic responsibility, economics, history and culture. In science, students will learn, among other things, about energy and energy transference, generators, building materials and design, global warming, the carbon cycle, and weather [appendix A]. Math standards will be included in many of the lessons including measuring, ratios, and arithmetic. In language arts, the students will be reading newspapers, journals, and text books and they will be keeping written journals as well as writing reports, arguments, and letters. The activities noted below touch on some of the standards and benchmarks addressed by this unit. More detail and extension is included in the activities described later in this unit. Whatever the age of the students, the goal for this unit is to offer knowledge and illustrate one instrument of change that can be replicated, simulated, customized, or personalized.

Taken in its current form, the unit's activities are written to address students living in northern New Mexico — referencing our natural renewable resources, our economy, and our culture. Most of our families are poor — within one or two generations of settling in this country. Our school is a charter school and has about twice the state average of special education students. That said, this unit can be adjusted to fit many different communities.

Objectives

The primary objectives in teaching this unit are to have the students understand the issues of global warming, gain a fundamental understanding of turbines and wind energy, and to articulate their knowledge to different groups with different backgrounds and purposes. There are secondary objectives including an understanding of the economy, politics, and social responsibility, as well as strengthening their skills in writing, reasoning, and researching. The instruments of learning will include lessons in the environment and ecology, the carbon cycle and photosynthesis, mechanical generators, wind turbines, solar energy, forensics, technology, weather, climate, fossil fuels, atmosphere, and global warming. Lessons addressing some of these concepts are included below.

Rationale

This unit is timely and relevant. Global Warming, or Climate Change, is considered a direct threat to the health of the planet and all us humans, plants, and animals on it. The statistics clearly show that the temperature of the Earth is rising alarmingly and there is no doubt as to the affect that greenhouse gases have on that increase. Example after example is cited in this unit description, e.g., 35% of soil moisture in vast growing areas of our country will be lost in the next 50 years if the CO_2 being emitted continues as "business as usual" [1].

Reducing greenhouse gases is the most important contribution humans can affect in mitigating global warming. Burning fossil fuels is the primary contributor to greenhouse gases, and the biggest source of useable energy on the planet is fossil fuels. Since it is unrealistic to expect humans to choose *less* comfort and convenience over current levels comfort and convenience, it makes sense to find alternative sources for the energy we need.

The Cape Wind project in Massachusetts is cited below as an example describing how alternative renewable energy production can make a significant impact on the amount of fossil fuels used and the associated increase in CO_2 and global warming. The Draft Environmental Impact Statement (DEIS) noted that Cape Wind would offset up to 113 million gallons of oil or a half million tons of coal annually and would not harm fishing, navigation, or tourism [4]. I think this experiment, or initiative, can be replicated and the savings to our environment, and ultimately our savings in dollars, will be tremendous.

In addition to learning about global warming, my students will learn to use new technologies. They will use the Internet extensively for both research and for accessing weather-tracking stations — both our own station and others across the country. They will also learn about power generators and turbines of different kinds.

My students will learn to speak with conviction and understanding, in public, about important issues. Having clear ideas and the ability to articulate those ideas is an increasingly important skill in the 21 st century. With the world community getting smaller (vis a vis the effects modern communications and commerce have between countries and cultures), it only makes sense that communication skills will be more and more critical for people of different cultures and languages to successfully collaborate on global issues. I hope my students will realize that people *can* make a difference — and that *they* can be difference makers. It is not only the "grownups," nor is it only those who get the best grades. It is the people who can form an argument, express themselves clearly, passionately, and persuasively — and it is people who have leadership. This unit has activities in presentations and forensics built-in that will help most students improve their communication skills, critical thinking skills, and logical and rational thinking abilities. I intend that this unit will help my students develop leadership and help them become comfortable and effective working with government and non-government organizations.

The experience and the learning they take with them from this unit will stay with them through their school years and, hopefully, beyond into their professional lives. The subjects of global warming and climate change, fossil fuels, carbon in the atmosphere, and alternative and renewable energy resources will remain in the forefront of important debate for years and years to come. I expect these students will use their knowledge in contributing to the discussion in a meaningful and effective manner.

In addition to the social responsibility side of this unit, the experience of working with and learning about the

weather-tracking station will help them understand weather phenomena and allow them to predict and plan according to science. The skills they build, working with technology, will be transferable to other important areas of their lives.

Background

Some facts about global warming that illustrate the serious changes we are confronted with concern the CO_2 concentration in the atmosphere and the associated rise in global temperatures. In the past 650,000 years, the concentration has fluctuated between about 180 parts per million and 260 parts per million (ppm). The average concentration has been near 230 ppm. Now, it is closer to 360 ppm and, at the current rate of growth, it will be over 600 ppm in the next 45 years [1]. CO_2 is the primary cause of global warming. Without getting some amount of control over its proliferation and working to bring atmospheric CO_2 levels down, global warming will change from being "an issue" to being "a crisis." Another fact that can be an eye opener is that of the 21 hottest years on record (since 1860), 20 of them have occurred in the last 25 years [1]. Part of my job, as teacher, is to impart a sense of duty, if not obligation, for each student/citizen to help keep their communities healthy.

Global warming has had disastrous effects on lakes in the world. In two examples, a drought is drying one lake up and a glacier's demise released the water of another lake into the sea. The first example refers to Lake Chad, which forty years ago was the size of Lake Erie. Now it is only 1/20 that size [1]. That in itself is horrible for the fish and the fishermen, the birds who use it in migration, and the water front towns and businesses. But, it is even worse for the people who depend on the fertile land around it. People who depended on the water have to find a new way to make a living, but the people who farm might have it even worse. As the shore recedes, they move their gardens, relative to the lakeshore location. Soon, they find themselves in *another country* where people do not look kindly on foreigners using their resources. Military confrontations commence and continue today in Darfur, Cameroon, and Chad. Morocco, Tunisia, and Libya each lose 250,000 acres of productive land a year to the desert [1]. In the second example, a lake in Chile spilled into the sea when a glacier, thinned by warming temperatures, broke up, releasing the water behind it [5].

In 1997, a group of countries, concerned about global warming, gathered in Kyoto, Japan and hammered out an agreement that would have them all cut their greenhouse gas production about 7% below the 1990 level by 2012. All countries were invited to sign the agreement. China, India, Australia, and the U.S. did not sign the agreement. These countries include the three largest single contributors of greenhouse gases. Under the agreement, so called "third world" countries do not have the same stringent rules for cutting CO_2 because they do not have the technology or a strong enough economy to do so. The U.S. position, as presented by the Bush administration, is that having different expectations for countries with advanced technologies and larger economies than for countries that are trying to catch up is not fair — so the U.S. will not sign the protocol without changes. The U.S. also wants to have a different scale of reduction that will make the targets easier to meet. Kyoto says the amount of CO_2 considered should be world wide — not based on individual countries — with the "haves" leading the way, allowing the "have nots" time to improve their infrastructure and meet the targets on a different time frame [6].

Renewable Energy (Wind)

In this section, I will present information about the topics mentioned above that will be taught in the "activities" or "lessons" section.

Historically, wind energy has been used as long ago as 5,000 BCE by the Egyptians to power their boats. By 200 BCE, the Chinese were using simple windmills to pump water and Persians were using windmills to grind grain. People in China and the Middle East made improvements in the technology and, by the 11 th century, European traders and fighters were bringing the technology back from their travels. The Dutch, for example, used windmills to pump water out of lakes and to drain wetlands, while European colonists making a life in the new world across the Atlantic used them to pump water from under ground for domestic use [7].

Steam engines eventually replaced wind pumps for getting water. Later, plants running on hydropower created electricity, which finally replaced steam. In 1890, in Denmark, technology improved and wind was used to drive turbines, which were used to generate electricity. In 1940, a wind turbine in Vermont was able to put out 1.25 megawatts in 30 mile per hour winds [7]. For more information on what watts are and how to make sense of how many are needed, see Michael Bluejay's web site about electricity [8].

Cheap fossil fuels after WWII caused interest in wind power to wane, but, after the oil embargo of the 1970s, new technology sparked renewed interest in wind-generated energy [7].

The first commercial wind farms in the US were in California in the early 1980s. In five years (about 1985), wind was generating about 1,000 megawatts (MW). It was not until 1999 that the amount was raised to 2,000 MW. In the last six or seven years, the capacity for generating electricity in California with wind has quintupled to over 10,000 MW. On an average day, enough electricity is produced with wind energy to power over 2.5 million homes [9].

There are some pros and cons to wind power. Some of the concerns and issues follow in this section. Wind energy may never have the potential of straight solar or some other renewables, but the cost has come down significantly in the past 25 years (currently, costs are between three and six cents per kilowatt-hour [10] depending on the source) from a benchmark of 80 cents per kilowatt-hour in 1980. The by-products of wind power are nil, and the efficiency is unsurpassed at this time. That said, startup costs can be more than fossil fuel generators and the only storage possible involves batteries. The areas that best lend themselves to wind generated power are open lands, like ranches, and remote rural areas. Wind farms make sense in these kinds of places because they don't take up much room on the ground and they do not create by-products. Areas that would be productive for wind power cover about 6% of the United States (lower 48) and could generate 50% more than the required energy needs of the country [11]. Note that I said that much area could *generate* that much power. I do not want to suggest it could actually *supply* that energy. The reason I make this distinction is the problem with the storage of electricity and the timing of peak demands. We cannot be absolutely sure when the wind will blow. Another estimate from the National Renewable Energy Laboratory suggests "with proper development, wind energy could provide 20% of this nation's energy needs" [12]. For this reason, even though the potential is tremendous, one has to be strategic in investing in wind power. Smaller wind turbines can be mounted on buildings like homes and produce enough electricity to make them practical. The main down side is that there *has* to be a certain amount of wind. Windmills are not nearly as noisy now as they used to be. Some people do not like the look of wind turbines — what can you say to that? In the early days of commercial turbines, some birds died after flying into the blades. With proper placement and slower moving blades, that problem has been mostly eliminated, though the problem has not been

entirely eliminated as evidenced by a Scottish project's environmental study for a wind farm [13].

Private homeowners can reduce pollution and avoid the volatile nature and cost of fossil fuel dependence by installing a wind turbine. But there are some other considerations. Perhaps the main issue is location — you would have to be able to put the turbine in a place that consistently has at least eight to ten mile per hour winds. Supporters of wind power might compare this to having to have a southern exposure for a satellite dish — but I think that might be a stretch. You can get a southern exposure by simply moving the dish around. The initial investment in wind energy can be significant, but the maintenance is almost nothing. Depending on the equipment you invest in and the cost of electricity in your region, the amount of time needed to recoup your investment can vary. If you live in a windy area, and you are connected to the grid, you can even sell excess energy back to the utility company.

To find out if an area typically has enough wind, you can check with the National Climatic Data Center, or the Wind Powering America Wind Resources website [9]. If their figures are border-line, you can do other things to judge your area, like use an anemometer (a wind measuring device) to find out if wind power will work for you.

In a way, wind is a type of solar energy. Wind is caused when two weather fronts come together. Weather fronts develop from the combination of the heating of the atmosphere and the rotation of the Earth, along with landforms and vegetation. I will discuss weather fronts more, later in this unit.

"Wind energy" is an expression used to describe the change of the kinetic power of moving air into mechanical power. That mechanical power is usually used to generate electricity via a turbine, to run a mill, or to drive a vehicle. When used to make electricity, wind turns electromagnetic turbines, which are connected to an electric grid. They can also be connected to specific utilities or appliances.

Wind turbines are generally either "horizontal-axis" style — the traditional two or three bladed windmill, or "Darrieus" style — which is named for the French inventor and resembles an egg beater [14]. Judging by the information I came across in my study, the difference in performance does not seem significant.

Two research areas currently being worked on in the wind energy field are "low wind speed technology" and the technology to store and distribute the power generated. In the mean time, organizations will build "wind farms" and individuals will install personal or small-community-sized turbines. These projects are not without detractors. In British Columbia (BC), Canada, a company called Dokie recently received permission to build a wind farm that will produce 300 MW [15]. Some of the arguments against the project include the potential danger to various migrating birds and local raptors. Some people believe that "green" companies (in particular the wind companies) have the process of approval smoothed out by politicians — letting the companies get away with less, or inappropriate, environmental impact research. One of the ways Dokie is accused of doing this is by copying bird data from another area that does not match the ridges of BC. They also worry that the work on the ground will disrupt not only the plants there, but will change the paths that migrating animals take.

To their credit, Dokie has verbally agreed to shut down any wind turbine that causes unacceptable harm, perhaps during bird migration periods [15]. These arguments will not likely end soon with the local citizens suspicious and the energy companies trying to take care of business and make money for their investors. While environmentalist Linda Sullivan says, "We still have concerns . . . where there is wind, there are birds," Ron Percival, Dokie president, argues that the energy is needed, and wind provides it with the *least,* negative consequence, "The fuel is free, abundant and . . . there are no carbon dioxide emissions" [15]. America's National Renewable Energy Laboratory supports the project, saying, "All energy technologies have some

negative environmental impacts. Society makes tradeoffs when making power plant choices" [15]. All things considered, it will be interesting to follow this project and see if the citizens involved find satisfaction or if, as the detractors suggest, it becomes another "Altamont" Altamont, is the early 80s wind farm in California that is known as being responsible for the deaths of raptors that hunt ground squirrels in the area. As an update and point of interest, the Altamont wind farm has been, and continues to be, modified with newer and safer technology including blades that turn slower and are higher so as to be less hazardous to wildlife.

Proponents of wind power say the risk of bird strikes has been overstated. The American Wind Energy Association cites a study showing that the leading cause of bird fatalities - more than half - is birds flying into buildings. Other major causes are cats, high-tension lines, vehicles, pesticides and communication towers. Wind turbines cause less than one bird death in 10,000, according to the study" [16].

Then, there is the issue of transmission costs: some of the best locations for generating wind are far from population centers. Some areas simply have a better, more reliable source of wind power. Though half the nation's installed wind power capacity is based in California and Texas, the greatest potential for wind generation can be found in areas where there is little demand for power [16].

Another proposed project worth following is the wind farm planned off shore near Cape Cod, Massachusetts. Here, Jim Gordon whose company, Cape Wind, is doing battle with residents. His plan will produce a "420-megawatt, 130-turbine wind farm . . . the project will supply about three-fourths of the power needed for Cape Code, eliminating about 4,000 tons of sulfur dioxide, about 1,000 tons of nitrous oxides, and about a million tons of greenhouse gases" [16]. Residents are concerned that their property will lose value if the wind farm is on the horizon and are arguing in court against the project. As of now, there are almost equal numbers who are for the project and against it, with a good number saying they are still unsure. In any case, wind energy is here to stay. Susan Cosier, in her Internet blog notes, "In the United States, wind power projects have grown from being practically nonexistent in 1980 to generating 11,603 megawatts of electricity in 2006, though today they account for less than 1 percent of the total electricity generated in the country. But by 2020, wind energy could represent as much as seven percent of overall energy produced, according to the federal Energy Information Administration" [17].

Global Warming

Global warming has been getting a great deal of publicity over the past year or two, so I will give a cursory overview to inform and build context.

When energy from the sun reaches our atmosphere in the form of light waves, it heats up the Earth. Some of the heat energy is radiated back into space and some of it stays in the atmosphere, keeping the temperature within the range needed to maintain life. The light energy entering the atmosphere includes infrared light, the part of the spectrum that provides warmth. A portion of those infrared light waves is radiated from the Earth, back into space. Certain molecules in the atmosphere (e.g. water and carbon dioxide) "capture" and hold infrared energy, causing the atmosphere to get warmer. There is a delicate balance between being too cold and too hot. For life to flourish, the temperature has to stay within a certain range, i.e., "just right." Because of this, Al Gore, in *An Inconvenient Truth* refers to Earth as "The Goldilocks Planet" [1].

Carbon dioxide (CO_2) is one of the infrared trapping substances in our atmosphere. There is a certain amount of CO_2 in the world. Carbon is in all living and formerly living things. When a formerly living thing oxidizes, the carbon in it is released into the atmosphere in the form of CO_2. The more carbon in the atmosphere, the more

heat energy from the Sun gets trapped and is kept from traveling into space [18, 19]. This carbon, in the form of $CO_{2,}$ is called a "greenhouse gas" because the effect of its presence can be compared to the effect of greenhouse glass that makes a greenhouse get hotter and hotter when the sun is shining on it. Unfortunately, the Earth's atmosphere does not have vents and fans to exhaust excessive heat to keep the plants happy. This is basically what "global warming" means. The tricky part is what to do about the human-caused addition of carbon into the atmosphere.

In Nature, a certain amount of CO_2 is floating around up there, keeping the temperature within the range needed to maintain life and except for an occasional wobble in the Earths axis causing an ice age or the like, that temperature stays remarkably consistent and comfortable. Humans, with our intellectual abilities have learned to use fossil fuels like coal and oil (really really really old life forms) to generate power for comfort and convenience. We do this mostly by burning it.

When the fossil fuel is burned, the CO_2 molecules that were part of it are released into the atmosphere. They go up into the atmosphere, absorbing heat, and along with all the other heat-collecting stuff up there, makes a sort of blanket around the planet. This "stuff," these gases that causes the earth to warm like a greenhouse, are called "greenhouse gases." Carbon dioxide is not the only gas that traps heat but it is the most effective and does a darn good job. In addition to coming from burning fossil fuels, greenhouse gas also comes from burning wood, livestock farms, and making cement [1]. Most of these greenhouse gases come from human use for the purpose of increasing our comfort and convenience. This is a simplified explanation of global warming.

The concern about the build up of heat is that it will change climates *around* the world. Depending on where on Earth you look, these changes caused by global warming can affect areas in different ways. For example, if the Arctic ice melts, instead of light waves hitting the snow and ice and reflecting heat, the light will hit darker ocean which will absorb heat — changing the temperature of the water and upsetting a delicate ecosystem, causing species to disappear. The differential in customary temperatures from global warming will be greater at the poles, causing glaciers and ice caps to melt and, subsequently, causing the seas to rise and inundate coastal cities. George Mitchell, former senate majority leader from Maine, said in 1991, "Unchecked, [global warming] would match nuclear war in its potential for devastation" [20].

There are direct correlations between human caused increases of CO_2 and increases of global temperature. So it behooves us humans to stop putting CO_2 into our atmosphere. Some people, even some scientists, believe that greenhouse gases and global warming are not that big a deal [20]. I am not here to argue that point. *Most* scientists believe without a doubt that global warming is: 1. real, 2. exacerbated by human activity, and 3. can be mitigated to some extent by responsible stewardship of the planet.

Turbines And Generators

In 1831, Michael Faraday discovered that when a conductor (e.g., copper wire) is moved (via mechanical energy) through a magnetic field, electricity will flow through the conductor — converting mechanical energy to electric energy. Other scientists improved the design of Faradays generator, until the modern generator emerged [21, 22].

If you use wind, water, or steam to turn the conductor, it is called a turbine. In a turbine, wings, or blades, give the source of power something to push against so it will turn faster and easier. Examples of different kinds of turbines include machines that use coal, oil, or gas to heat water into steam, which turns the turbine. Falling

water from behind a dam can turn the turbine, or wind can turn the turbine. Depending on the resources available — e.g., is the site of interest near a river, on a open prairie, or near a forest), a person would decide which kind of turbine to build.

Weather

The particular weather phenomenon that I will address here is wind. When people say that wind is a form of solar energy, they are not far off the mark. When the sun warms the air on Earth, it excites the air and makes it move — mostly up. As the Earth rotates, friction pulls the masses of air along with it. The uplifted air tends to lag behind the air closer to the Earth because the friction is not as strong up there. Moving areas of weather are either called high pressure, usually led by a cold front, or low pressure led by a warm front. Both high and low pressure systems rotate, with high-pressure systems turning clockwise (in the northern hemisphere) and low-pressure systems turning counter clockwise. When low- and high-pressure systems overtake each other, the high-pressure system will either push under the low pressure or the low will slide over the high pressure. This differential between low and high, the spinning areas of pressure, is what causes wind. These interactions combined with moisture in the air are responsible for different types of clouds and cloud cover and their associated weather [23].

As it applies to wind energy, it makes sense that you would want to set up your turbines in an area where weather systems and fronts are likely to bump into each other. It would also be beneficial to set up in areas that tend to have less moisture to avoid severe thunderstorms.

Since air moving across the surface of the Earth is slowed somewhat by friction, you would want to take advantage of Bernoulli's Principle. This would work because the "front," or weather system, moves as a body of air. If the body of air is compressed or forced to move in a smaller space, it will speed up. This explains why ridge tops are good for wind farms — as the air mass moves up the hill, its profile will get thinner, the pressure will decrease, and the wind will accelerate [24, 25].

Forensics, Persuasive Discourse, and Research

When Dick Smothers told his brother, Tommy, all the reasons why he was wrong on some argument and then waited to see how Tommy would respond, he was usually greeted with a moment of silence in consideration of possible options before finally confronted with a, "Well, OH YEAH!?" This answer did not typically put Dick back on his heels. We don't have to be an Abraham Lincoln to make a good argument, but we have to be prepared. Our students do not have much, if any, experience in constructing a rational and convincing line of reasoning. There are steps to take to prepare a persuasive presentation [26].

First, it is important that the speaker know that they are communicating to the listener in both verbal and non-verbal means. In addition, they have to know they can engage in communication by observing their listener — who is also communicating non-verbally (and possibly verbally as well). It is also important to account for the location of the presentation. If the speaker is going to be giving a talk in a conference room, it would not be in their best interest to practice outside in a football field — better if they practiced in a large room with a big table and a projection screen (if a screen is going to be used). Other important aspects to consider are to know your audience — what are their needs and desires. Like an artist, use your white space — i.e., silence can be an effective way to make a point. Give your audience a chance to process or digest your ideas. Visual aids are good, but do not rely on them. YOU are giving the presentation. And do not read your PowerPoint slides or talk over them if you want your audience to read them. Speaking of reading, having a handout with the topic and major points on it to give to the audience is a good idea. This way, the audience can get an

overview of the presentation and main points before you start — allowing their brains to access whatever prior knowledge they have. In addition, they will have something to write questions and elucidating comments on. Finally, it will help keep the audience engaged because they will know where you are in your talk and they will know where you are going.

If the purpose of the presentation is to persuade, which is true in the case of this unit, it is important for the speaker to recognize that and *not* try to include entertainment into their talk. Gear your main points to address the needs of your audience and stay focused on the *main point* you want the audience to leave remembering. The truth is that groups do not usually remember everything that speakers talk about. So, the speaker has to know his or her purpose and gear their talk to address the main ideas they want the listeners to remember. Sam Walch of the Department of Speech Communications for Pennsylvania State University teaches his students to formulate a residual message, which is a "specific statement of what you want your audience to remember long after you finish speaking" [26].

Strategies, Activities, And Lessons

This unit is a pretty long one and there will be many more lessons than what you see here. The selected lessons represent different sections of the overall unit — some of the lessons came from units already presented by me or other teachers, some are new.

Just as continued reading, researching, discussing, and experimenting will lead to additional knowledge for me, it will indirectly lead to additional lessons and knowledge for my students. So, I am deliberately allowing some wiggle room for adding and modifying my lesson activity schedule. For those interested in using this unit, I will happily provide a more detailed list of activities used [27].

The full list of activities will include hands-on experiential activities, reading and reporting, demonstration/observations, field trips, guest speakers, videos and more.

What follows are some samples of the class activities I intend to use in this unit. They are presented in the order in which I *plan* to use them.

Examples

What is Energy?

Energy is the ability to do work. Energy makes lights glow, radios play and you can feel it. In this lesson, students will brainstorm different types of energy and discuss the different ways energy is used, by humans, animals, and Nature. Students will also discuss the different natures of energy — be it volatile or benign. The lesson will culminate with an activity where the students hold hands in a circle, with two adjoining students holding the terminal ends of a hand generator (not too powerful). The class will feel the energy passing through them. As one student at a time leaves the circle, the current will get stronger. Students will discuss and keep a journal about their experience, including such things as what they expected to happen, what did happen, and what would happen if the current were changed. The journal will also contain their thoughts, observations and findings regarding the nature of energy.

What Is Global Warming?

Global warming comes from excess CO_2, and other greenhouse gases, preventing heat from escaping Earth's atmosphere.

There are several parts to this activity. The first part will include discussions concerning the causes of global warming and the consequences. Students will take notes from lectures by their teacher and a guest (local renewable energy expert). They will view videos made by Al Gore [19], United Streaming [28], an NPR series of cartoons about the carbon cycle [18], and a special video on global warming by Discovery Education on United Streaming [29]. This lesson should take about two days. Students will work in small groups, comparing notes and doing follow up research. After they have a fundamental understanding on the academic side, they will use experiments to solidify their understanding.

Students will demonstrate some effects of global warming and experience the greenhouse effect via experiments and hands-on activities. One of the activities on global warming has to do with the temperature difference between covered versus open containers by using thermometers and beakers in the sun. Students, in small teams, will put ice and water in the beakers. One of their beakers will be covered with plastic wrap and one will be covered with a foam lid. One will be open. They will use their thermometers to measure the temperatures in beakers of water over time. They will track and graph their data on all three beakers. Different groups may use different locations for their study (e.g., window sill, open ground, shaded or protected ground). Then, students will hypothesize about their results — before and after the test.

Another experiment will demonstrate how melting ice caps and glaciers will affect the sea's levels. Using a water table, students will construct a model coastline with a sea. Ice, representing the polar ice cap, will be placed on the water and left to melt. After observing and discussing the results, more ice will be placed on the land representing glaciers. That ice will be allowed to melt as well. Further observations, note taking, and discussion will follow.

Each of these lessons should take one day.

Additional global warming lesson ideas can be found in the "Additional Reading and Resources for Teachers" at the end of this unit.

How Does Global Warming Change the Arctic, Arctic Sea ice and Inuit people?

In this lesson, students will read in a website about cultural issues that global warming is forcing certain people to deal with [30]. Students will also research Arctic people on Internet sites and in library books. They will also learn about the native perspective on the juxtaposition of tradition and the modern age from a Native American guest speaker.

Since my students live in close proximity to Native American culture, this part is notably relevant in their lives. Native peoples do find conflict between their "traditional" culture and the modern culture of America (e.g., technological advances, family relations, and real estate management). My students will compare the changes imposed on native peoples in different places and eras. They will follow up their study on this part with a short (500 — 800 words) report.

Alternative Life Styles

Students will complete a Webquest, exploring alternatives to fossil fuels [31].

Webquests are guided research projects. The Webquest they will use instructs them in their research steps and understanding the resulting products. Their teachers will help guide them and correct misdirection periodically.

Designing a Windmill

There are two strategies to this part. In both, students will view videos and pictures of different windmills. They will discuss what we know about their uses (students will have read and studied extensively on the history and mechanics of wind power).

Students will be challenged to design a windmill model (in teams) that will actually work. Each group will be given a budget and access to "the store" where they will have choices of what materials they wish to buy for their project. If students create a valid argument for additional materials that are not available in "the store," then the teacher will determine the practicality of obtaining those materials and proceed accordingly.

They will have one day to come up with a plan. On day two, we will share ideas and revise plans. On day three, we start work, and on day four, we review the students' progress and make decisions about continuing with our plan. If the class is doing well, we will continue for another week.

Some examples of materials they can buy are; straws of different sizes, paper towel and wrapping paper tubes, popcycle sticks, plastic bottles (gallons and two-liter), bearings and lubrication, scissors, dowels, wood boards, lamps, wire, magnets, glue (hot and cold), rubber bands (different sizes), clay, string, and "other." Each team will get a small motor and everyone will have access to wind (hair blowers and different fans). Many of these items are used in commercial wind turbine kits.

The back up plan is to have 10 kits to use for the students to build. We can also use the kits as a model to help them in their own design efforts. See "Additional Reading And Resources For Teachers" for information on PicoTurbine, a resource for wind turbine plans and kits.

At the end of this lesson, we will test the windmills using lamps and LEDs. We will also measure with an amp/volt meter.

If You Build It, Will It (Wind) Come?

Students will take notes from a lecture and forum by windmill expert about locations — considering landforms, prevailing weather patterns, political concerns, and proximity to the grid. They will follow the talk by doing their own research about where to locate a wind farm. Student research resources will include the lecture and forum, Internet (news stories and professional journals), maps, and personal journals. They will use PowerPoint to present their decisions to the class.

Are You Going To Believe Me, Or Your Lying Eyes?

Students will construct a convincing argument for allowing a windmill to be constructed on the school grounds using their learning over the past several weeks. The teacher will help guide and lead them in developing their case. They will learn to present it through argument and debate, practice in front of other classes, and they will deliver their final presentation before the Santa Fe County Commission and New Mexico State Legislature.

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http://www.knpb.org/teacherline/images/lessons/ FossilFuelsAlternativeFueling.pdf

Additional Reading And Resources For Teachers

PicoTurbine, http://www.picoturbine.com/home.htm

A resource for wind turbine kits. About $35 each or 10 for $300

PicoTurbine, http://www.picoturbine.com/ picoturbine-plans.htm

This site has free plans for building a turbine with your own materials.

"Environmental News". Cape Wind. July 9, 2007

www.capewind.org

Information about the Cape Cod wind farm including articles, videos, history.

Moore, Thomas Gale. Global Warming, A Boon to Humans and Other Animals, Stanford

University, 1995

This book argues that global warming is actually a good thing. This is a good reference to use in debate.

"How an Electric Generator Works" Wisconsin Valley Improvement Company

http://www.wvic.com/how-gen-works.htm

This website gives you a visual interactive model of a basic generator.

"How to Plan and Prepare Presentations". Word Doc. July 9, 2007

http://www.awwa.org/conferences/speakers/ How_to_Plan_and_Prepare_Presentations.doc

This website takes you to a PDF article about how to plan and prepare presentations. There is no author noted and the information is useful.

Gore, Al. An Inconvenient Truth. Emmaus, Pa: Rodale, 2006.

This is the seminal book on global warming written in easy to understand language. The video of the same name is also good. The video is good for catching the students eye and interest. The book is better for more intensive study (e.g., you can spend more time on the before-and-after photos and graphs).

West, Larry. "Should the United States Ratify the Kyoto Protocol?" Ask.Com. July 9,

2007

http://environment.about.com/od/ kyotoprotocol/i/kyotoprotocol.htm

This article offers a more in depth review of the Kyoto Protocol than what most people ever see.

TIME magazine. Special Double Issue, Global Warming Survival Guide. "51 Things You

Can Do to Make a Difference". (69-100) April 9, 2007

This issue of Time magazine has 51 easy to read essays on things most people can do to shrink their carbon foot print. The issue also has other pertinent articles on energy.

Britt, Robert R. "Weather 101: All About Wind and Rain." Live Science. July 9, 2007

http://www.livescience.com/ environment/weather_science.html

This website offers a primer in basic weather science. It is a good resource to review the nuts and bolts of weather.

Montagne, Renee, and Hamilton, Jon. "U.N. Report Suggests Ways to Cut Carbon

Emissions". NPR. July 9, 2007

http://www.npr.org/templates/story/story.php? storyId=10000163

Audio and written U.N. Report suggesting ways to cut carbon emissions, consisting mainly of simple lifestyle changes.

"Cycle Series: The Carbon Cycle". United Streaming. July 9, 2007

http://www.unitedstreaming.com/search/assetDetail.cfm? guidAssetID=71192B42-8058-4A7F-885C-BFCDC6C76962 &tabStart=videoSegments

United Streaming is a great resource for uncountable topics. This link refers you to a series of five short videos that describe and explain the carbon cycle. You may need a password to get in.

Johansen, Bruce E. Global Warming in the 21 st Century. Praeger, Westport, CT. 2006

A three-volume treatise on global warming including, books on the climate crisis, the warming of the oceans, and the impact on plants and animals.

Hassol, Susan Joy. "Teachers' Guide to HighQualityEducational Materialson

ClimateChange and GlobalWarming". National Science Teachers Association (NSTA). July, 9 2007

http://hdgc.epp.cmu.edu/teachersguide/teachersguide.htm

Top 10 things to know about global warming and an annotated list of resources

and links including some lesson plans from the Department of Energy.

"Home Page". Climate Change.org. July 9, 2007

http://climatechangeeducation.org/

Global warming general site with links.

"Global Warming/Climate Change Theme Page". Community Learning Network. July 9,

2007

http://www.cln.org/themes/global_warming.html

List of sites about global warming.

Merrill Richard, Gage Thomas. Energy Primer; Solar, Water, Wind, and Biofuels. Dell,

NY. 1978

This is a classic book on basic energy issues and topics is written in relatively short chapters. It has copious pictures, charts and graphs. It also offers resources to use to put your learning into practice along with 1978 prices. The "wind" section starts on page 120.

Lesson Resources For Teachers

"Teacher's Lounge". Atmospheric Radiation Measurement Program (ARM). July 9,

2007

http://education.arm.gov/teacherslounge/ lessons/alphalessons.stm

This is a collection of science lessons including lessons on global warming.

"Bringing Climate Change Into the Classroom." PDF. No author or home site. July, 9 2007

http://education.arm.gov/teacherslounge/ lessons/climate_change.pdf

This PDF gives a good background on Arctic ecosystems. At the end, there are

some lessons to use in support of the PDF.

"Search Engine for Teachers". Lesson Planet. July 9, 2007

http://www.lessonplanet.com/search/ search?keywords=Global+Warming

This site has links to 434 lessons on-line. I did not look at every one, but they appear to be mostly science lessons.

"Comm Tech Lab Home Page". Michigan State University. July 9, 2007

http://commtechlab.msu.edu/sites/ letsnet/noframes/subjects/index.html

Many good green lessons listed on this site.

"LetsNet". Michigan State University, College of Education. July 9, 2007

http://commtechlab.msu.edu/sites/letsnet/ noframes/index.html

This is another extensive lesson resource. You may need permission to access

this site. Check with "http://www.educ.msu.edu/" if you are refused access.

"Weather Discovery Center." Mount Washington Observatory. July 22, 2007

http://www.mountwashington.org/ education/center/arcade/

This site has some nifty, simple experiments that explain some weather phenomena.

"Bernoulli's Principal" Think Quest. July 22, 2007

http://library.thinkquest.org/27948/bernoulli.html

Appendix A

New Mexico State Standards Addressed

The strands, standards, and benchmarks noted are not intended to be an exhaustive listing.

Science

Strand I: Scientific Thinking and Practice

Standard I: Understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically.

5-8 Benchmark I: Use scientific methods to develop questions, design and conduct experiments using appropriate technologies, analyze and evaluate results, make predictions, and communicate findings.

5-8 Benchmark II: Understand the processes of scientific investigation and how scientific inquiry results in scientific knowledge.

5-8 Benchmark III: Use mathematical ideas, tools, and techniques to understand scientific knowledge.

Strand II: Content of Science

Standard I (Physical Science): Understand the structure and properties of matter, the characteristics of energy, and the interactions between matter and energy.

5-8 Benchmark III: Describe and explain forces that produce motion in objects.

5-8 Benchmark II: Explain the physical processes involved in the transfer, change, and conservation of energy.

Standard II (Life Science): Understand the properties, structures, and processes of living things and the interdependence of living things and their environments.

5-8 Benchmark I: Explain the diverse structures and functions of living things and the complex relationships

between living things and their environments.

Standard III (Earth and Space Science): Understand the structure of Earth, the solar system, and the universe, the interconnections among them, and the processes and interactions of Earth's systems.

5-8 Benchmark II: Describe the structure of Earth and its atmosphere and explain how energy, matter, and forces shape Earth's systems.

Strand III: Science and Society

Standard I: Understand how scientific discoveries, inventions, practices, and knowledge influence, and are influenced by, individuals and societies.

5-8 Benchmark I: Explain how scientific discoveries and inventions have changed individuals and societies.

State Standards in Social Studies

Standard I

Benchmark -A—New Mexico: Explore and explain how people and events have influenced the development of New Mexico up to the present day.

Standard III

Benchmark-B— Explain the significance of symbols, icons, songs, traditions, and leaders of New Mexico and the United States that exemplify ideals and provide continuity and a sense of unity.

Benchmark-D— Explain how individuals have rights and responsibilities as members of social groups, families, schools, communities, states, tribes, and countries. Benchmark

Standard IV

Benchmark-A— Explain and describe how individuals, households, businesses, governments, and societies make decisions, are influenced by incentives (economic as well as intrinsic) and the availability and use of scarce resources, and that their choices involve costs and varying ways of allocating.

Benchmark-B— Explain how economic systems impact the way individuals, households, businesses, governments and societies make decisions about resources and the production and distribution of goods and services.
