

Savvy Energy Consumers: Evaluating Our Energy Costs and Determining Alternative Resources

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Objectives

This is my first year teaching as a regular education teacher in a classroom of my own. This is also my first year at Alfred G. Waters middle school and teaching sixth grade. I teach two classes of science and two classes of math. My objectives for this project have changed greatly due to my change in location, grade and placement. Since I teach two subjects, I wanted to reshape my objective so that I can incorporate goals for both math and science. I also would like to expose students to real world problems that can be solved through scientific processes and mathematical practice, which they are currently mastering.

At this middle school, students are issued an iPad at the beginning of their sixth grade year. It is each student's responsibility to ensure that it is fully charged at the start of each day. When a middle school student charges his device, he knows electricity is coming from the outlet in the wall. He most probably knows that the source comes from overhead or underground wires from the power plant. But where does the power plant get its source? What does that cost his school and family? How can he help alleviate that cost? The objective of this curriculum project will focus on the source of consumer electrical power in our local area and how that initial source was created and attained. Students will research and determine the district cost for this resource and how they can help lower that cost. Our district is voting on a referendum to increase revenue for the construction of new schools due to overcrowding. Many residents are alarmed by the percentage of district budget that is spent on energy. Community members at local town hall meetings have inquired as to what research has been done to lower costs for current and future energy expenditures. To meld the science and literacy expectations together, I want my students to research our school energy demands and persuasively communicate both in writing and in a presentation how this high usage of electrical energy can be solved, scientifically, at the local level. For the final objective, students will use the evidence they gather to evaluate a system to reduce costs. Students may select an alternative energy source to reduce the overall energy cost to their school. The culminating project will be a persuasive writing piece presented to the class with individual ideas to lower consumer costs. Throughout this curriculum unit, students will research background through informational text, design an experiment with controlled variables, and connect problem solving to mathematical skills.

Demographics

District

Alfred G. Waters middle school is part of the Appoquinimink school district located in Middletown, DE. Our population has grown by 5% since last year and is projected to continue to increase over the next ten years due to the influx of families to new construction in the area. The Appoquinimink school district welcomed over 500 new transfer students to raise the total number of students to more than 10,400 in a community of 66,500 people. Due to this projected growth, the district will be voting to determine if a referendum can be passed to raise money to build three new schools and upgrade three existing schools to meet the capacity needs. Alfred G. Waters school currently holds four classes in trailers and the construction of a new middle school in the community would alleviate our overcrowding.

School

Alfred G. Waters school houses 937 sixth to eighth grade students, 334 of which are sixth graders. According to the Delaware Department of Education, 16.1% of Alfred G. Waters Middle School's students are African American, 7.5% are Other Minorities, less than 5% are Hispanic, and 71.9% are White. There is little variation in the socio-economic background, 8.8% of our students are from a Low Income household.

Classes

Most middle school teachers at Alfred G. Waters school teach one content area to four classes each day. I teach two classes of math and two classes of science each day. For this reason, I do not have any students classified with special education needs. However, 10% of my students have a 504 plan for emotional, physical, or academic accommodations. Class sizes range from 28 to 32. My students are very diverse learners with varying degrees of ability. Most of my students have similar backgrounds and experiences in this community. The hope is that the community link of this project will foster interest and drive creativity.

Background of Students

Science

Appoquinimink school district has been a member of the Delaware Science Coalition for several years. This coalition was based on the Delaware State Science Standards and supplied participating districts with curriculum, teacher training, and science materials throughout the year to support and drive instruction in the science classroom. With the adoption of the Next Generation Science Standards, our district has found the coalition slow to update current curricula to incorporate more rigorous content and embrace supporting science practices. Therefore, our district is piloting a new science curriculum

called Project Based Inquiry Science, which is written by Its About Time. The district has been given a curriculum and limited teacher training to pilot an introductory launcher unit and two full units per grade at the middle school level. Teacher and classroom supplies are created and purchased by district personnel or directly from the publisher. It is the district's goal that the use of this outside curriculum will better foster Next Generation Science Standards into daily teaching and student investigations as well as save money. Sixth grade teachers have been given a launcher unit to familiarize students with the scientific process and science practices created by this publisher. The first full unit focuses on Earth's materials and systems. The second full student unit taught this year is forces and motion, focusing on electric and magnetic forces.

My intention for this curriculum unit is to pull information students learned in their earth history and forces and motion science units to show the relationship between the two. I intend to teach students how fossil fuels are formed from the geologic changes of earth over time and how these fuels are used to produce electricity, which in turn power their devices at school. This power comes at a cost, which is paid for by their community. Current overcrowding and population increases of the area create a need for more power and thus more revenue. Evaluation of current expenditures at the school level will allow students see what resources cost and how this cost can be lowered. Discovery will be made by direct instruction and individual research of informational text. Students will be able to explain the difference between fossil fuel types due to differences in geologic process and time. This information will help students understand the original source of their energy, the availability and expected cost of fossil fuels, and why adults in their community are looking to lower these costs.

Math

The Appoquinimink district has also adopted a new curriculum for the middle school population named Envisions written by the Pearson Publishing group. Prior to this curriculum, middle school lessons, workbooks, and assessments were teacher created based on the Common Core State Standards for math. The major emphasis of sixth grade math is to understand ratio concepts and reasoning to solve problems. The subsets of this standard focuses on unit rate, creating tables and graphs demonstrating relationships between ratios, and the solving of problems involving unit pricing and constant speed.

Students currently understand the basic four operations with rational numbers. However their understanding of rational numbers includes integers, fractions, and decimals. The relationship of rational numbers such as a fraction is internal, the relationship of the numerator to the denominator and that a simple fraction has a value of less than one. Throughout this curriculum, students will learn that rational numbers will have a relationship with other numbers and that relationship can be expressed as a rate. My intention is to draw upon what student's will learn in math class about unit rates and relationships, to have students determine the rate of energy use of their school.

Connections to mathematical practices of ratios and proportional reasoning will be repeatedly utilized as students predict and calculate energy usage rates. Students can then determine the costs of energy usage and transform units to the rate of energy usage over time and represent this change graphically.

Science Background

Fossil Fuels

The US energy sources as of 2015 can be broken down to natural gas-methane 29%, petroleum (oil) 36%, coal 16%, nuclear 9%, and renewable energy 10% (geothermal 2%, solar 6%, wind 19%, biomass 49%, hydroelectric 25%). Fossil fuels comprise over 80% of our national fuel for energy. Fossil Fuels are composed of petroleum, coal and natural gas and make up 82% of the world's energy supply¹ (Agency, 2016). The benefits of fossil fuels are the high energy density and versatility for energy use in various applications. Fossil fuels are known as non-renewable resources because they are found in limited supply. Extraction of these fuels from under the earth's surface can cause disturbances in the land and lead to environmental impact of habitats that can occur in already sensitive areas. Fossil fuel supplies have been decreasing steadily which can lead to unconventional extraction and production of these products.

Fossil fuels are the product of dead organic marine plants, microorganisms and organisms that sunk to the bottom of swamps and oceans approximately 360 to 286 million years ago during the Carboniferous period in the Paleozoic Era (Smil, *Oil: A Beginner's Guide*, 2008). Over millions of years, sand, clay and other materials settled over this decomposing material forming sedimentary rock. As more and more rock piled on top, the weight increased, pressure increased and water was squeezed out of the organic material. This subjected the organic material to intense heat and pressure and converted it to a fossil fuel. The differences in fossil fuels is due to the origin of the organic material, how long the material was buried, and what temperature range and pressure that matter was subject to.

Petroleum or oil was originally small marine plant life called zooplankton and algae. The organic material died and sunk to the bottom of the ocean and formed a spongy material called peat. Oil forms under a limited range of temperatures called the 'oil window'. The geologic formations which encapsulate oil underground are called reservoirs, and are comprised of sedimentary rock, and have tiny spaces which hold water, natural gas or oil. Cap rock is void of reservoirs and surrounds this holding the reservoir in place. Oil is composed of mainly hydrogen and carbon, or hydrocarbon

¹ Agency, U. E. (2016, November 21). *Electric Power Annual*. Retrieved November 21, 2016, from <http://www.eia.gov/electricity/annual/>

molecules. Sulfur, Nitrogen, and Oxygen are also found in oil in trace amounts. The viscosity of oils is dependent upon the type and amount of bonding between the carbon and hydrogen atoms in the substance (Smil, Energy, 2006).

Natural gas formed from the same beginning ingredients as oil, yet natural gas underwent further decomposition than oil due to a longer period of time under a wider range of temperatures and pressure.² Natural gas is primarily composed of methane, a carbon atom with four covalently bonded hydrogen atoms. Natural gas has small amounts of other hydrocarbons. Dry or biogenic natural gas is greater than 95% methane and wet or thermogenic natural gas is less than 95% methane with a mix of butane and ethane. Natural gas that is commonly found alongside oil is called associated gas, and is extracted in combination with oil. Once extracted, natural gas is purified and can be liquefied for transportation.³ When burned, natural gas emits almost half the carbon emissions of coal, leading to less carbon dioxide production. However methane itself is a greenhouse gas and has 32 times more potential to lock in thermal energy in earth's atmosphere than does carbon dioxide.

Coal formed when plant life like ferns and trees died and fell into swamps, which preserved the organic material and prevented complete decay.⁴ Sedimentary rock layered over top of this material over millions of years subjecting it to intense heat and pressure which formed this hardened fossil fuel. Coal is classified by the percentage of carbon it contains. The greater the percentage of carbon the higher the grade of coal, the cleaner it burns, and the greater demand there is, due to it being more versatile. The lowest grade of coal is lignite or brown coal, which is only 25-35% carbon. It has higher contents of hydrogen and oxygen, a lower content of carbon, and a lower energy content. Sub-bituminous coal is 35-45% carbon with a lower sulfur content. Both are almost exclusively used as fuel for electricity power generation. Bituminous coal is 45-86% carbon and looks black with bands of bright and dull material. It too is used in electricity production, heating, and steel making. Anthracite coal is the hardest type. It is a black shiny coal composed of 86-97% carbon, has the highest energy content and is used in home heating and steel making. Coal is the primary fuel for 40% of the world's electricity production⁵.

² Shelia Olmstead, *Wastewater and Shale Formation Development: Risks, Mitigation and Regulation* (New York: CRC Press, 2015), 84-115.

³ Arthur Kidnay, William Parrish, and Daniel McCartney, *Fundamentals of Natural Gas Processing 2nd Edition* (Boca Raton: CRC Press, 2011)

⁴ Vaclav Smil, *Oil: A Beginner's Guide*. (Oxford: Oneworld Publications, 2008)

⁵ Agency, U. E. (2016, November 21). *Electric Power Annual*. Retrieved November 21, 2016, from <http://www.eia.gov/electricity/annual/>

Fossil fuels are composed mostly of carbon based on weight. Combustion of fossil fuels causes the carbon to bond with atmospheric oxygen and produces carbon dioxide, which enters the atmosphere increasing the amount of greenhouse gases. Greenhouse gases prevent heat from exiting our atmosphere, trapping it in and causing global temperatures to rise. Burning fossil fuels also causes other products in the material such as sulfur, mercury and nitrogen to be released into the atmosphere, which can lead to acid rain and pollution.

Electricity Generation

Electricity for community use is produced at power plants and transported via transmission lines to buildings. But what is electricity and how is the energy transformed from one substance (i.e., coal) to the charger of a student's iPad? Electricity is a form of energy involving the movement of charged atomic particles called electrons which transfer energy from one atom to the next. Electrical energy is generated by the transformation of other energies to electricity, which can be easily transported to homes and businesses for use.⁶ Students need to learn the connection between the formation of fossil fuels within the earth and the production of electricity to power their devices.

In Delaware, 85% of power plants are fueled by natural gas and 8% are coal fired. Most of this natural gas is piped in from Pennsylvania. Natural gas contains stored chemical energy. When burned the chemical energy is transformed into thermal energy and heats water in a boiler to a temperature of at least 100°C to produce steam. The expanding steam causes a dynamic pressure, is captured in the boiler and channeled to flow past the fins of a turbine converting thermal energy to mechanical energy. The steam is then cooled, condensed back into water and returned to the boiler to restart the process. The movement of the turbine causes the spinning of a connected shaft that is connected to a generator. Here the mechanical rotational energy is transformed into electrical energy. Inside the generator the end of the shaft is surrounded by a highly conductive coiled copper wire which are encased in a large magnet. As the copper wires spins inside the magnetic field of the magnet, an electric current is induced. The flow of electrons travels the length of the wire to high-capacity transmission wires, which enable the electrical energy to be transported to other areas. The transmission wires are connected to the electric grid by a network of power lines. Electricity travels through high-capacity lines, to a substation, to smaller distribution lines, transformed to a lower voltage that is safe to use, to the interior of a building and ultimately to an outlet. Electrical energy travels into one prong, through a device, and out the other prong, completing a circuit that provides the energy to charge an iPad or similar device.

⁶ Vaclav Smil, *Energy* (Oxford: Oneworld Publications, 2006).

School Use of Electricity

In the Appoquinimink school district, our school purchases electrical energy from Delmarva Power.⁷ The local power plants which supply electricity to this area through Delmarva Power are located in Delaware City with an output of 23 megawatts and Smyrna with an output of 96 megawatts. Consumers are charged by the kilowatt hour (kWh) which is the total energy in kilowatts delivered in one hour. The average kilowatt hour charge was 9.65 cents in Delaware in 2015. The district spent \$1,615,915 in total energy costs in 2015. Our school uses an average of 7.5 kWh per square foot per year. The school is 11,000 square feet which factors to a yearly power usage of 82,500 kWh or yearly cost of \$7,961.

Strategies

Background information on formation of fossil fuels and conversion of chemical energy to electrical energy was taught in the first two full student units this year. Ratio relationships were taught in previous math units this year. This curriculum unit is intended to be a culminating activity for the sixth grade year, which will encompass one week and can be used as a cumulative project as a summative grade. Students will learn about the upcoming district referendum through direct instruction. They will be presented with details of current district expenditures and the proportion of that total which is energy. Ratio relationships between energy costs and total costs to run a district will be discussed. We will discuss how energy is needed for heating buildings and water, but our primary focus will be on electrical use to power lighting, computers, air ventilation and cooling in the district. Next students will see the individual breakdown of electrical costs for their school throughout a calendar year. This will be presented graphically so that student can learn how usage and costs change throughout the year. Discussions will focus on what months have higher costs and why. Are higher costs due to the number of students present, weather, season, and amount of daylight, special events or holidays? Students will receive a graphic organizer (Appendix B) and modified copies of last month's and current electrical bills, and will be taught that energy is based on Kilowatt-hours, a ratio of the amount of electricity used per hour. Pictures and videos of electrical meters will be used to help show students how the number of kilowatts used each hour in a building are determined⁸. Student will then be prompted to factor the number of kWh used at our school during the past month by subtracting the previous month's meter reading from the current meter reading. Students will find the kWh rate on the current bill and multiply it by the number of kWh used to determine the current electric fee for their

⁷ Graves, L. (2012). *Source Watch*. Retrieved November 21, 2016, from http://www.sourcewatch.org/index.php/NRG_Dover_Energy_Center

⁸ "Appoquinimink Referendum Calculator", last modified November 21, 2016, http://www.apposchooldistrict.com/tax_calc.jsp

school. Given the average monthly total expenditures for the school, students will determine the ratio of energy that our building uses to the total monthly costs. Lastly, students will compare this ratio to the percentage of the district's budget that is used for energy. They will determine if our school's ratio is higher or lower than that of the district. Group discussions will help determine if and why there is a discrepancy between the two. Once a relationship is made about the proportion of money needed for energy use, and the push for a referendum to pay for rising costs, students will be challenged to lower our school's energy costs.

Before students research ways to decrease electrical costs, students need to understand the source of their electrical power. Students will be asked to discuss in groups from where this electricity comes which powers their iPads. Students will then complete a KWL (Appendix C) to determine where they think electricity comes from, what they would like to learn about powering their iPads, and a part to be completed later about what they have learned. Questions to be answered on the sheet include: How does electricity get to our school? Where does electricity come from? How is it transmitted? How is electricity supplied to so many places at once? Do you have electricity transmission lines near your house? How is electricity for your area generated? Is electricity generated the same way all across the country? What are some other ways to generate electricity and where in the country do you think these methods are most in use? Groups will then share ideas with the class to discuss ideas of electrical sources. Students will watch a video depicting an animated power plant where a fossil fuel is burned to create steam to power a turbine to power a generator to transform to electrical energy to a school. Students will complete a graphic organizer during the video. Student will then go back to their KWL to list what they have learned about the source of electrical power to their school.

The majority of power plants in Delaware are steam turbine powered by natural gas.⁹ In order to better understand how a steam turbine creates electricity, students will create model aluminum steam turbines following a specified procedure¹⁰. The objective is to teach that chemical energy in a fossil fuel is released via combustion and converted to thermal energy, which heats water and converts it to steam. The pressurized steam allows for the transformation of thermal energy to mechanical energy when it causes the fins on the turbine to move. The mechanical energy can be transformed into electrical energy in a generator. In addition, students are exposed to variables in the experiment. Discussions

⁹ "Delaware State Profile and Energy Estimates", accessed November 21, 2016, <https://www.eia.gov/state/analysis.cfm?sid=DE>

¹⁰ "Going For a Spin, Making a Model Turbine", accessed November 21, 2016, http://energyforkeeps.org/wp-content/uploads/2011/08/Pages-1-7-from-ch2_activities.pdf

emphasize that variables in the models can lead to changes in the speed of the turbine. Variables discussed include the energy source and size of the turbine.

Students are separated into groups of four and each group creates one aluminum turbine. To incorporate a variable, four different sized turbines are built by the class: 3, 3½, 4, and 4½ inch diameters so that students can compare class data at the end to determine if turbine size affects speed. Throughout the lesson students are asked what other variables can effect the spinning of the turbine. Two groups are assigned to each size turbine. Students are given a procedure sheet (Appendix D), data sheet, and calculation sheet.¹¹ After creation of the turbine, groups determine how fast their turbines spin by measuring the revolutions per minute (rpm) in three trials. Groups also measure the diameter of their turbine to calculate the circumference. Next the speed of each group's turbine is calculated by multiplying the circumference by the rpm.¹² Group data is shared with the entire class. The class graphs the turbine size versus the speed, analyze their results and determine if turbine size effects speed.

Now that students understand the origin of their electrical power in their classroom, students will look at the cost of this service to their school. Unit costs of energy includes the electricity and delivery of that service to their school. To relate this concept of electrical energy generation to students in school, students will be given a partially completed mock electrical bill for their school. A teacher led lesson shows students to find the number of kWh which were used at the school in one month. Students will then complete a math activity where they are given the price of kWh in their community. Students must then compute what their school bill would be.

How can this cost be reduced? Thinking back to variables that can change the speed of a turbine, classroom discussion will focus on changing the power source of the turbine. In the classroom activity, water was heated to create steam with an electric hot plate. Class instruction stressed that natural gas is the predominate energy source for steam turbine generators in Delaware. Discussion will ask students to complete a list of energy sources that are not fossil fuels to either heat the water or turn the turbine. After class discussion, students will individually research alternative energies for 5 minutes on their I pads. As a class we will list ideas. If the class was unable to come up with alternatives,

¹¹ Marilyn Nemzer, *Energy for Keeps: Creating Clean Electricity from Renewable Resources* (Tilburon: Energy Education Group, 2010)

¹² Dvorak, P. (2013, September 23). *How to calculate blade tip speed, and more* . Retrieved November 21, 2016, from Windpower Engineering Development: <http://www.windpowerengineering.com/design/mechanical/blades/calculate-blade-tip-speed/>

give students the following alternative energies to be explored: nuclear, solar, wind, hydropower, geothermal, and biomass. Students will be assigned to groups of five students to research and present the ability to use these energies at the school or community level.. Groups will construct a poster and presentation will be done in a gallery walk style. Criteria for the research includes: Is this a renewable or non renewable resource? How much of this resource is used in the US? How does it work? What are the advantages of this energy? What are the disadvantages of this energy? When is this energy available? What is the average kWh cost of this energy to a consumer? During the gallery walk, all students will be given a graphic organizer to record the above criteria for each of the 6 alternative energies.¹³

The culminating activity will allow each student to choose which alternative energy source they feel would help alleviate energy costs for our school. Using the same criteria as the poster presentation, students will write a persuasive letter to the school board stating why use of their chosen alternative energy will reduce costs. Students will then individually present their letter to the class.

¹³ Sherman, R. (n.d.). *Renewables Are Ready*. Retrieved from http://www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_energy/renewablesready_fullreport.pdf

Resources

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Appendix A

There are three Next Generation Science Standards addressed in this unit:

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor).

There are seven Grade 6 Math Common Core State Standards addressed in this unit:

Ratios & Proportional Relationships, Understand ratio concepts and use ratio reasoning to solve problems.

CCSS.MATH.CONTENT.6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

CCSS.MATH.CONTENT.6.RP.A.2

Understand the concept of a unit rate a/b associated with a ratio $a:b$ with $b \neq 0$, and use rate language in the context of a ratio relationship.

CCSS.MATH.CONTENT.6.RP.A.3

Use ratio and rate reasoning to solve real-world and mathematical problems

CCSS.MATH.CONTENT.6.RP.A.3.A

Make tables of equivalent ratios relating quantities with whole-number measurements, find missing values in the tables, and plot the pairs of values on the coordinate plane. Use tables to compare ratios.

CCSS.MATH.CONTENT.6.RP.A.3.B

Solve unit rate problems including those involving unit pricing and constant speed.

CCSS.MATH.CONTENT.6.RP.A.3.C

Find a percent of a quantity as a rate per 100; solve problems involving finding the whole, given a part and the percent.

CCSS.MATH.CONTENT.6.RP.A.3.D

Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

Appendix B

Name: _____ Core: _____ Date: _____

Calculating our School's Energy Costs Worksheet

October, 2016 Energy Bill (page 1)

ACCOUNT NUMBER	DATE DUE	AMOUNT DUE
XXXXXXXXXX	11/14/2016	\$207.28

Delmarva Power
 PO BOX 19003
 Wilmington, DE 19801

Visit us on the Web
www.delmarvapower.com

CUSTOMER NAME AND ADDRESS	ACCOUNT	BILL DATE	NEXT READ
A.G. Waters School 1253 Cedar Lane Rd. Middletown, DE 19709	XXXXXXXXXX	10/21/2016	11/18/2016

SERVICE ACTIVITY			
Meter No.			
XXXXXX			
	Reading 10/18/2016		74500
	Reading 09/19/2016		- 65000
	Electricity Used (KWH)	=	_____
ELEC			
	_____ KWH at \$0.12061	=	_____
	Daily Customer Charge (30 days at \$0.18740)		50.62
	DE Low Income Assistance Fee		30.15
	Total Electric Charges	=	_____

Average Monthly Operating cost of School = \$4,092.13

Ratio of Energy Use = _____

Appendix C

Name: _____ Core: _____ Date: _____

KWL Worksheet

What do you know?
How does electrical energy get to our school?

Want to Learn
What would you like to learn about powering your Ipad?

Learn
What have you learned about electricity in our school?

Appendix D

Name: _____ Core: _____ Date: _____

Turbine Procedure Worksheet Circle Group Turbine Size 3, 3½, 4, or 4½ inches

Materials Needed:	Aluminum pie plates	Metal funnel	Compasses
Rulers	Pencils	Plastic Straws	Scissors
Timers	Markers		
Push pins	500ml Beaker	Hot plate	Oven mitts

Procedure:

1. Using your compass, measure and draw a ___ inch diameter circle with a pencil on the aluminum pie plates. Divide the circle into halves, then fourths, then eighths (marking the divisions by drawing your pencil down the straight edge of the ruler). As shown in the diagram, cut the circle into 8 blades by cutting along the 8 divisions on the solid lines, to within ¾ inch (2 cm) of the center. Make sure not to cut all the way to the center.



2. Taking each blade, bend one side gently up (along the dashed lines) so that all blades are curved up the same direction.
3. Using the marker, color the entire front edge of one blade.
4. Using a push pin, attach the turbine to a straw at one end.
5. Teacher constructs a class steam device at a central station.
6. Test your turbine by blowing on it, to simulate the energy of steam. Gently make adjustments to the turbine blades to get the most spin.
7. Using the heat source, fill the beaker ¼ full of water and bring to a boil. Wearing oven mitts, place the steam device on top of the pan.
8. Wearing an oven mitt, hold your turbine face down over the funnel opening where steam is escaping. Hold the turbine over the funnel opening again and raise and lower it slowly to see at which height it will spin fastest.
9. Using the timer, record the number of revolutions the turbine spins in one minute. Repeat this for two more trials. Record your data on the data sheet.

Appendix E

Name: _____ Core: _____ Date: _____

Turbine Data Worksheet

Our Turbine's Diameter: _____

Revolutions Per Minute (RPM)

Trial 1	Trial 2	Trial 3	Average

Circumference and Speed of Turbine

Diameter of our turbine	Formula $C = \pi r^2$	Circumference of our turbine	Average RPM	Speed of our Turbine Circumference x Average RPM

Class Turbine Speeds

3" Diameter	3½" Diameter	4" Diameter	4½" Diameter

Graph of Turbine Speed versus Turbine Diameter:



