

# PROJECT REPORT

Northern Wyoming Community College District / National Science Foundation  
Summer Energy Education Program 2012

Terry Lewis  
June 27, 2012

## TITLE

**Electric Energy From Coal – Is it good or bad?**

## SUMMARY

The purpose of this unit is to demonstrate how energy can be transformed from one form into another using a simple model for electrical current detection and generation. Students will compare their model to a state of the art coal power plant from Wyoming. Students will come to understand that coal mining and generating electricity from the mined coal can be viewed from multiple perspectives and will have a chance to share their initial feelings about the processes. Students will collect information on the processes and differentiate between the beneficial and problematic aspects of coal-mining. They will share their findings and the class will come up with “areas of concern” to investigate. After considering the information presented by the teacher about Dry Fork and analyzing the hard data from this state of the art coal mining project, students will re-evaluate their initial views on coal mining and be able to support this stand with data collected.

## ENERGY CONTEXT

Energy cannot be created or destroyed but it can be transformed from one form to another. Coal is a source of chemical energy and tapping that energy has many benefits, but the processes involved can be problematic. Resourceful, innovative, and creative scientists, using data and the scientific method can develop techniques and procedures to make the transformation of energy from stored chemical energy inside the coal to electrical energy efficient, safe and economical.

## ANTICIPATED TIME REQUIRED

### **Total Time Required - 10 days**

The calendar of events for this project is as follows:

- Day one: Initial questions, KWL survey, electric current detector activity
- Day two: Simple model of electricity generator
- Day three: Energy conservation and transformation discussion – Earth History of Carboniferous Era video and discussion, sharing of dinosaur footprints photos, stromatolites, and oil shale samples.
- Day four: Coal Mining attitude activity (Kid blog and Vote with your body – Pre assessment to ascertain level of understanding of good and bad aspects of coal mining and power generation. Discussion of the necessity of gathering data before making value judgments. Generation of a list of things we as a class want to know about coal mining and categorizing these queries into groups for research.
- Day five: Group students for Google doc work. Discuss citation methods and how to evaluate a good resource and identify bias within a website. Set up shared accounts and go to media to begin research. Each group (3 students) has an area of inquiry and must find 3 resources that address that area.
- Day six: Students share what they have learned about the advantages and disadvantages of coal

mining. Google docs will be saved so that all students have access to them. A list of “areas of concern” will be generated as a class after the discussion.

- Day seven: Teacher shares Power Point of what was learned about the operation of Dry Fork Coal Mine and how scientists have solved or addressed many of their areas of concern regarding coal mining.
- Day eight: Students examine a diagram of the Dry Fork Power plant and compare it to the simple model generator they made in the classroom. They will discuss how they are similar and different and how the model aids their understanding of the operation of a power plant. Teacher shares more facts about the economics and efficiencies of this particular Power plant and how much of their electrical power comes from the Powder River Basin. Students are asked to recall all the uses of electricity we came up with on day one and to think about how their lives would change without electricity. Students will use Kid Blog to show how their attitudes toward coal mining are changing and why.
- Day nine: Reclamation and government control – using Dry fork as an example students will discuss the ethics of government control – how much is enough, how much is too much, what is the purpose, what is accomplished. Areas of discussion include; 20 % energy must come from renewables, money must be set aside in a bond so land can be reclaimed if company goes bankrupt and land needs to be restored to original conditions.
- Day ten: Students will write an essay as an assessment to demonstrate what they have learned about coal as a source of energy, how a power plant works and how to use engineering and innovation to solve problems that arise in power generation.

#### **INTENDED STUDENT LEVEL**

This series of activities, investigations, discussions and assessments is intended for 9<sup>th</sup> grade students studying earth science.

#### **ASSUMED PRIOR KNOWLEDGE**

**It is assumed that students have prior knowledge of:**

- Internet etiquette and citation procedures
- Concepts of basic magnetism and basic electricity
- How to write an essay
- How to work together in a group using Google Docs

#### **LEARNING OBJECTIVES**

- Understand the concepts of conservation and transformation of energy and be able to apply these concepts to the process of coal mining and generating electricity in a coal powered power plant.
- Predict how changing a certain variable in an experimental model of a generator will affect the operation of the model.
- Compare and contrast the simple generator model produced in the laboratory to a functioning state of the art power plant. Generalize how the basic principles in operation within the model are the same basic principles that operate in the actual power plant.
- Assess the model to determine its shortcomings in predicting some of the challenges encountered in a real coal powered power plant.
- Draw on actual data to formulate their own opinion about the use of coal to provide energy. Be able to support their opinion both in writing and verbally.
- Differentiate between opinion and fact when discussing the advantages and disadvantages of electricity from coal.

- Evaluate methods used by scientists and engineers to improve coal mining processes and power production processes to increase safety by removing harmful substances from waste products.
- Recommend changes in government policies such that exploration of renewable resources is valued and continued but conservation and use of all products related to coal mining is also encouraged and rewarded.
- Incorporate what they have already learned about erosion and habitat preservation to prescribe appropriate techniques and constructions that would be effective in reclaiming the land after mining is completed.

## MATERIALS

### Materials needed:

For the two laboratory experiences each group of students will need:

- Construction of Electrical Current Detector:
  - 1 meter of bellwire, one compass, wire strippers, flashlight battery, lantern battery
- Construction of Model Generator:
  - 2.5 meters of varnished or enameled copper wire (Insulated wire works but not as well), toilet paper roll, bar magnet, and current detector made with equipment above.

For research and compiling group data each student will need a computer with Internet capabilities and a gmail account for google doc work. They will also need to be logged onto KidBlog.

- A smart board or presentation technology is helpful for students to use when presenting their research findings.
- Teacher will need power point presentation capabilities and access to youtube for History of the Earth Video.

## INTRODUCTION / MOTIVATION FOR STUDENTS

**Students are asked a series of questions about electricity. These questions are designed to determine what they know about electricity already and to motivate them to want to generate an electrical current in the classroom. Suggested questions are:**

1. List as many things in this room as you can in two minutes that use electricity.
2. Cross off all the things on the list you don't really need. Put an asterisk next to the things that are crucial to our survival. Share list with partner, share with class, what generalization can you make about our dependence on electricity?
3. Where does our electricity come from? How much does it cost? Why does it cost so much?
4. How do you know there is electric current flowing? What can be used to detect electricity?
5. Do you think we could use these simple objects (hold up wire and magnet) to generate an electric current?

## PROCEDURE

### Experimental procedure:

Current detector:

- Divide class into groups of three – four students pass out materials and procedure sheet. (attached)
- Have students follow procedure and answer questions.
- Debrief by going over questions as a class

Electric generator:

- Divide class into groups of three – four students pass out materials and procedure sheet. (attached)
- Have students follow procedure and answer questions.
- Debrief by going over questions as a class
- Show demo generator that turns on light bulb by turning a crank that rotates a coil of wire inside several horseshoe magnets. (Available from Flinn)

**Discussion:** use questions that follow to get students to realize that in order for us to get electric energy some other form of energy must be transformed into this energy and a good source of stored chemical energy we could use is coal.

- Did we really “create” electrical energy with our generator?
- If we didn’t create the energy, where did it come from?
- What did we have to do to the magnet in order to generate a current?
- What happened when there was no movement?
- What kind of energy is moving energy?
- We are able to move the coil or magnet because we are alive and able to transfer energy from out body to the magnet. How do we get energy?
- Can something dead have energy? What is it died millions of years ago and got buried in a swamp in the cretaceous period? What might it become?
- Where is the energy in coal and oil stored?
- What do we need to do to get this energy and transform it into electricity?

**Video** section on stromatolites and the cretaceous period from “History of the Earth” from the History Channel

**Sharing** of fossils collected in Wyoming: stromatolites, dinosaur footprint photos, dinosaur bones, dinosaur bone photos, oil shale sample.

**Attitude survey** (collect initial impressions about coal mining, Kid Blog, and vote with your body activity.)

**Discussion** on data gathering before making judgment about coal mining and using coal in power plant.

Sample questions:

- Why do you think you feel the way you do about coal mining?
- Do you think you voted based on facts or opinions or hearsay?
- How might we make a better decision about coal mining and power conversion?
- What do we need to know?

- a. What's bad about burning coal?
  1. Wastes (CO<sub>2</sub> Sulfur, arsenic, nitrates, ash)
  2. Landscape
  3. Transportation
  4. Wildlife
  5. Working conditions
  6. Limits
  7. Cleaning and inspection costs
- b. What's good about burning coal?
  1. Abundance
  2. Efficiency
  3. Economy
  4. Weather dependency
  5. Refinery
  6. Foreign dependency
  7. Storage

**Divide students into research groups** and have each group pick one of the areas above to research. Set up groups on Google docs and remind them how to pick a reputable website and cite it.

After research students should present what they have found while rest of class takes notes. They should use smart board for presentation.

After presentation class should be directed to come up with a list of concerns about coal mining and processing.

Each group should be given the charge: If you were going to design a mine and processing plant what would be your major concerns. What problems would you set your engineers out to solve? After groups have worked separately for a few minutes create a class "List of Concerns." A sample list should contain the following:

1. How can you make the coal burning cleaner?
  - a. How will you know if it is clean (low amount sulfur compounds, arsenic, nitrates?)
  - b. How will you collect the fly ash?
2. Are there cleaner sources of coal? Where are they? How will you find them?
3. How can some of the waste products of coal burning be disposed of or better yet utilized?
  - a. What will you do with the sulfur?
  - b. What will you do with the ash?
  - c. What will you do with the CO<sub>2</sub>?
4. How can you cut down on transportation costs?
5. How can you make sure your employees remain safe?
6. How can you have the least impact on the environment (global warming) and the wildlife habitats?

**Next show the power point** (attached) on Dry Fork to give examples of what the scientists and engineers have already done to solve many of these problems.

Compare the power plant at Dry Fork to the model generator made by the students on day two. Show slide of diagram of power plant and one of diagram of model generator. Detect all the differences and similarities and list them for students. Some important comparisons follow:

Concept	Model	Dry Fork
Source of Energy	sun energy transformed plants into food source, cell respiration transformed sugars into ATP to turn magnet	Sun energy was transferred to plants and animals and decay processes during the cretaceous stored the energy in coal
Involves living or once living things	Yes, student power was needed	Yes, coal was once alive
Burning (oxidation) is involved	Yes, cellular respiration creates ATP	Yes, coal fires release chemical energy
Mechanical energy is involved	Yes, turning magnet or coils	Yes turning turbines
Coil of copper wire cuts through the magnetic lines of force	Yes	Yes
There is some waste CO <sub>2</sub>	Yes, breathing minor amount	Yes, burning major amount
Noxious gases may be expelled	No	Yes
Economic source of power	No	Yes

Using Dry Fork as an example, **students discuss the ethics of Government Control and reclamation.**

Sample discussion questions:

1. Should the government insist that part of the electrical power sold by the powerplant come from renewable resources? What are the advantages and disadvantages of this practice?
2. Is there ever a time when there is too much government control? Would energy be cheaper if there were no controls? Would this be a good thing? Who should decide how much control to exert?
3. Should the government force Dry Fork to create a bond ( a large sum of money set aside in an escrow account) so that if the mine company goes bankrupt there is some money set aside to reclaim the land? What are the advantages and disadvantages of this practice?
4. Should the reclamation process be ongoing or should the company wait until they are completely finished mining before they begin reclamation?

### SAFETY ISSUES

Caution students to use standard safety procedures when in the laboratory. There are no particularly dangerous substances used in the laboratory section of this unit.

### TROUBLESHOOTING TIPS

Students must wrap the wire around the toilet paper cardboard in a very regular manner. This can be difficult for some of them. You can purchase professionally made selenoids from Flinn as an alternative.

Getting all students involved in a discussion is always difficult. Use the Kid blog for students to write out their thoughts from time to time during the discussions. This will help them remember what they want to say if they get a chance and it will give you a chance to get some informal formative assessment material to let you know how they are doing and if they are getting the major concepts.

## ASSESSMENT

### Project Assessment:

#### Pre Assessments (three types)

##### 1. Introductory assessment:

Question/Answer

- Listing electrical devices/ answer varies but speed with which they come up with list is indicative of preliminary understanding.
- Where does our electricity come from/powder river basin/ prairie island power plants
- What do you need to produce electric current in the classroom/ magnet, coil of wire, current detector.

##### 2. Pre-activity Assessment Predictions;

Each of the two labs ask students to make predictions;

- Will electric current be generated when the magnet stops moving/no
- Does it matter if N or S pole is pushed in and out of coil/ no but compass needle swings opposite way
- Does it matter if coil is moved or magnet is moved/ no

##### 3. Pre research and instruction attitudinal survey assessment:

Original attitude toward coal mining and coal driven powerplants is also a pre-assessment. There is no right or wrong answer but this is used as a baseline to see how successful the instruction is at the end.

### Embedded Assessments

The conclusions questions in each of the lab activities can be useful in measure understanding. They are not graded, but are formative in nature and students are asked to correct their mistakes.

The entries into Kid Blog can be used to measure understanding on a formative level. It is important to look for growth and increased understanding of the processes involved.

When students are asked to do research on a particular benefit or drawback of coal mining/ power plant use there are definite things that must be considered. This is a formative assessment to see if the students came up with the major concepts – however it is not graded and any misunderstandings are corrected by the teacher.

Some things to look for are:

#### Challenges:

1. Wastes
  - a. CO<sub>2</sub> emissions cause global warming
  - b. Sulfur emissions cause acid rain
  - c. Ash contains the poison arsenic
2. Landscape strip and open pit mining makes huge caverns in the landscape.
3. Transportation – it costs a lot of money and energy to transport the heavy coal
4. Wildlife do not do well in the area around the coal mine
5. Coal mines and power plants have dangerous working conditions and there are diseases like “black

lung and cancer that are associated with coal mining.

6. We have only a finite amount of coal – enough to last us only 200 years. We must develop other sources of energy to supplement our coal.
7. The methods used to clean the smoke stacks and filter out the ash and toxic chemicals is quite costly and paying people to go around and conduct inspection tours is also costly.

**Benefits:**

1. Abundance – there is more coal than oil and natural gas in the united states
2. Efficiency – Coal is easily burned and generates a lot of energy for its mass
3. Economy – Coal is much less expensive to harvest than other forms of energy (oil and gas)
4. Weather dependency – Unlike the wind and solar power coal is not dependent on the weather (sunny days and consistent moderate winds)
5. Refinery – Coal does not need to be refined – just mine it and use it
6. Foreign dependency – Since we have such large supplies of coal – using it for energy decreases our dependency on foreign oil and eliminates political issues and unnecessary alliances.
7. Storage – Coal can be stored safely and transported safely- we do not have to worry about oil spills in the ocean or breaks in gas or oil pipelines.

**Post- Activity Assessment:**

The summative assessment will be an essay written by the students. The essay will have four parts:

Part One: Describe what you have learned about how coal is mined and how it is used to generate energy in a power plant. In this part compare the model generator made in the lab to an actual coal power plant, describing the similarities and difference as well as the limitations of the model.

Part Two: Describe the benefits and challenges of coal mining and turning coal into usable energy in a power plant. Also describe how engineers have creatively overcome the challenges facing the coal industry.

Part Three: Re-evaluate your original opinion of the coal mining and power plant process and tell how your opinion has changed because of the data you have collected or how the data collected has served to reinforce what you believed earlier.

Part Four: Consider the ethics of government control and regulation on the coal industry and its effects on the economics and reclamation process.

**Rubric for each part:**

Students should give evidence that they understand the concepts of energy conservation and transformation as it applies to the coal industry. They should include the following in their essay:

How coal stores chemical energy and how that energy can be converted into electrical energy in a power plant by burning the coal.

How and when coal was formed / by processes of pressure and temperature during the Cretaceous period.

Where coal is found and what steps must be taken to retrieve it and transport it before it can be burned.

Students should give evidence that they understand the relationship between magnetism and electricity demonstrated in the model generator and they should show how those same principles operate in the power plant and they should describe the limits of the model. They should include the following in their essay:

When a coil of wire cuts across a magnetic field, an electric current flows.

It does not matter whether you turn the magnet or the wire coil when generating the current.



Current can be measured with a simple compass apparatus or a galvanometer.

The simple generator and the power plant use the same basic principle listed above and both need a mechanical energy supply for the turning.

The model has limits – it does not predict the challenges encountered when coal is burned in a power plant.

Students should be able to describe 5-6 benefits of coal mining and power generation and 5-6 challenges faced by the coal industry. They should also understand how engineers used scientific processes and knowledge to meet 2 specific challenges. They should include the following in this section of their essay:

Information from formative assessment on benefits and challenges listed above.

Any 2 of the following problem solving applications:

Sulfur recovery methods and marketing of material

Carbon dioxide recovery and recycling into oil mining processes

Fogging machine collects ash and reuse of ash materials

Students should show evidence that they understand the difference between a pure opinion and a value-judgment based on fact by transforming their original opinion into a more valid generalization based on facts. This section should include:

Their revised opinion and at least 5 facts to support it.

A discussion of opposing opinion and the facts to contradict that opinion

Students should describe the types of controls the government places on coal mining and processing and be able to look at these controls from the perspective of the mine owners and investors, environmentalists, government officials and local community. This section should include:

A description of the controls in place at the present time.

They should discriminate between the benefits and drawbacks of these controls seen by 3 different groups.

They should make their own recommendation regarding government control of the coal industry. Their recommendations must be based on facts.

### **SUGGESTED EXTENSIONS**

This project lends itself to an extension related to careers and skills and knowledge necessary for these careers. As you have studied the coal mining and power plant process you have seen that it takes many different people doing very different jobs to make the entire process come together.

1. As you have heard about all the different aspects of the mining and processing at Dry Fork what kinds of careers appeal to you? Why does this career appeal to you? What kind of knowledge, skills, education would you need to follow this career?
2. What kind of skills and background knowledge should the mine look for when trying to hire someone to head up the reclamation project?