# PROJECT REPORT

**Northern Wyoming Community College District / National Science Foundation**
**Summer Energy Education Program 2011**

**Callan Bentley**
**August 12, 2011**

## TITLE

NOVA Energy Corporation Invades Wyoming

## SUMMARY

Students will learn about fossil fuel reservoirs in Laramide basins of Wyoming. They will use case studies as exemplars to guide a simulated exploration activity wherein they will map and interpret the distribution of oil and coal resources. These maps will be documents that guide a hypothetical commercial exploitation of the coal or oil based on economic parameters including the cost of extraction and the market price of the fuel. Estimates of the total reserves will be calculated based on assumptions of porosity, grade, and other parameters. The final extraction plan will be presented as if to a board of directors for approval. The presentation will emphasize oral communication skills and quality visualizations, and students will also be evaluated with the ensuing discussion.

## ENERGY CONTEXT

Coal and oil are energy-rich geologic resources which formed through the natural sequestration of biologic carbon (removed from the atmosphere by plankton and swamp plants millions of years ago through photosynthesis) under conditions of sedimentary deposition. These buried 'fossil fuel' reserves are potentially lucrative sources of income for those who can locate, extract, and sell them, as well as mitigate negative environmental effects.

## ANTICIPATED TIME REQUIRED

This project will require:

- Set up experiment – 10 minutes
- Introductory discussion and lecture – 30 minutes
- Conduct experiment – 15 minutes
- Summarize research – 10 minutes

## INTENDED STUDENT LEVEL

This project is aimed at community college Environmental Geology students, though it would probably also be appropriate for a high school course in Environmental Science, if the instructor had a sufficiently geological bent.

## ASSUMED PRIOR KNOWLEDGE

This project will assume that students have prior knowledge of:

- Trigonometry
- Compass directions
- Strike and dip of planar geologic structures
- Topographic maps
- Group work etiquette
- “Slideware” presentation software such as PowerPoint

## LEARNING OBJECTIVES

- Recognize that isolated outcrops of rocks may be correlated geographically to deduce subterranean structure.
- Comprehend that the extraction of fossil fuels such as coal, oil, and natural gas is an expensive and laborious endeavor.
- Conclude which resources are likely to be found in a basin, given its geometry and geology, and which of those resources are economically feasible to extract.
- Practice developing and presenting a plan of action to a skeptical corporate board.

## MATERIALS

***The class needs:***

- LCD projection capability (with computer equipped with PowerPoint and Google Earth)
- Samples of oil shale, lignite, bituminous, sub-bituminous, and anthracite coal.
- Hot plate and beaker (with water) to artificially “thermally” mature the oil shale.

***Each group needs:***

- Blank topographic map worksheets of their model basin. Station numbers are already pinpointed.
- Data sheet with one of four possible coal or oil or oil shale datasets – rock types found at each numbered station, and the strike and dip of the strata at that location.
- Colored pencils
- Computer with PowerPoint or equivalent slideware presentation suite.
- Calculator with trigonometric functions.

## INTRODUCTION / MOTIVATION FOR STUDENTS

The energy we use has to come from someplace. Geologic reservoirs of carbon may be utilized by combining them with oxygen in an exothermic reaction. The heat released by this reaction may be used to drive a piston, turning a crankshaft, making an automobile go, or it may be used to heat water, which makes steam, which turns a turbine, which makes electricity, which may be transmitted to power laptops and charge iPods and other functions essential to society’s functioning.

## PROCEDURE

**Day 1**

- Lecture: introduction to Wyoming geology (Laramide structure), coal, and oil using PowerPoint slideshow.
    - Regional-scale structure of Wyoming
    - Depositional basins vs. structural basins vs. drainage basins
    - The formation of coal
        - Lake and swamp flora; ages of US coal deposits
        - Clinker
        - Coalbed methane
    - The formation of oil
        - Phytoplankton, photosynthesis, burial, anoxia
        - Thermal maturation, migration, sources, reservoirs and traps
        - Oil shale and tar sands
    - Case studies of Wyoming basins: Green River Basin and Powder River Basin
- Demo begins: oil shale.
- Geologic map of Wyoming – worksheet to compare basin geometry.
- Identify and describe representative rock samples from Wyoming.
    - Sample A = orange sandstone of the Chugwater Formation
    - Sample B = limestone of the Madison Formation
    - Sample C = black shale of the Thermopolis Shale
    - Sample D = conglomerate of the Cloverly Formation
    - Sample E = sandstone of the Morrison Formation
    - Sample F = sandstone, shale, and coal of the Fort Union Formation
    - Sample G = oil shale (kerogen-rich marlstone) of the Green River Formation
    - Sample H = white sandstone of Newcastle Formation with black plant fragment fossils
    - Sample I = green flat pebble conglomerate of the Gros Ventre Formation
    - Sample J = conglomerate and sandstone of the Wasatch Formation

**Day 2**

- Group work – hypothetical Laramide basin “field work” with information on rock types and structural information (strikes and dips of strata) at 42 stations. Four groups total – each group gets the same base map, but a different suite of lithologic and structural data, which will result in different maps and different conclusions about the accessibility of different resources.
- Students create map; use map to plot a strategy for extracting one of the fossil fuel resources through one of the approaches discussed.
- Students in each group present their “pitch” for a resource extraction plan to the rest of the class and the instructor, who play the role of the board of directors of NOVA Energy Corporation. The board then asks questions of the presenters, and their responses are evaluated.

**Day 3**

- Check on oil shale experiment – has oil been produced? If so, how much?
- Discuss the energy input necessary to extract petroleum from oil shale, and what this does to the economic appeal of this resource.

## SAFETY ISSUES

During the demonstration portion, and for 45 minutes thereafter, be sure that the students don’t accidentally knock over the beaker of hot water (and oil).

## TROUBLESHOOTING TIPS

If the students are rusty on trigonometry (for drawing the cross sections and projecting them into the subsurface, consider reviewing “SOHCAHTOA” with them before the activity or with low-math-skills teams during the activity.

## ASSESSMENT

***Pre-Activity Assessment***

*Question/Answer:* Ask the students and discuss as a class:

- Where does our energy come from?
- How do fossil fuels generate energy?
- How do we get our fossil fuels out of the ground?
- How do we transform fossil fuels in order to utilize them?

***Activity Embedded Assessment***

*Question/Answer:* Ask the students and discuss as a class:

- What do we do as exploration geologists when our available data don’t make a sensible map pattern?

***Post-Activity Assessment***

*Question/Answer:* Ask the students and discuss as a class:

- Is it an easy business to find, extract, and deliver fossil fuel energy to the marketplace?
- What complications are there to fossil fuel extraction and utilization that are unrecognized in this activity?
- How would you change this activity if you had to teach it yourself to a group of high school students in an Environmental Science class?

## SUGGESTED EXTENSIONS

Several extensions readily suggest themselves to me as a community college instructor from Virginia:

1. A comparison of Virginia coal and oil reserves to those of Wyoming. More broadly, a comparison between all the energy resources between a specific state where the lesson is being taught and Wyoming. In Virginia, common energy resources include coal, wind, and uranium, though Virginia’s coal reserves are far less than Wyoming’s. Virginia’s wind potential is strongest offshore; Wyoming’s in flat Laramide basins. An extension on this extension might be an comparison of how Wyoming and Virginia might fare in the face of climate change predicted at several different levels of global warming induced by anthropogenically-liberated atmospheric carbon.
2. A field class specifically examining the geology and energy resources of Wyoming, conducted during the summer term. This course could be modeled on a hybridization between a pre-existing Regional Field Geology of the Northern Rockies field course currently taught at my Virginia community college, and the NSF summer energy workshop for teachers Wyoming Energy Resources field trip led by Tom Johannesmeyer.

3. Carbon capture and sequestration [CCS] estimates based on point source burning of fossil fuel (coal-fired power plants), and strategies for CCS for non-point source $CO_2$ generation. For instance, atmospheric concentrations of $CO_2$ are around 390 ppm (as of August 2011); the flue gas from the Dry Fork Power Plant near Gillette, Wyoming, was about 14%, or 140,000 ppm. Using hand samples of sandstone or limestone, students could make laboratory measurements of porosity, permeability, and then calculate specific retention volume. Students could use their own geologic maps as guides to overall volume of rock with desirable carbon storage reservoir characteristics, and suggest where suitable subsurface reservoirs are, and what their volumetric capacities for carbon storage might be. Lastly, they might examine their proposed $CO_2$ reservoirs for hazard potential (leakage, fault triggers, *etc*.).