Title: Natural Gas in Arkansas WebQuest

Author: Charlotte Cook and Gene Williams
Carver Magnet Elementary School
Little Rock

Course: Science, Social Studies, Literacy/Writing and Technology, Math

Grade Level: 4th and Higher

Duration:
Tasks:
- Elementary 3-4 hours
- Middle and higher 1-3 hours

Assessments:
- Elementary 1-2hours
- Middle and higher 1-2 hours

Objective:
Students will explore the properties of natural gas, how it is extracted, and the economic impact of natural gas on Arkansas through the use of technology. They will pose a question about geology to a real geologist and receive a response to their questions.

Summary of Lesson:
This WebQuest will help students of various ages gather information to understand the natural gas industry in Arkansas. Students will work in small groups or as individuals to build a foundation of knowledge about the industry. There are 4 tasks to be completed to help students to understand the natural gas industry, why it is important to Arkansas and to gain knowledge about the fracturing that is used to extract the gas from the shale in our state. Students will use a template/informational text sheet to record the information they gather.

The 4 tasks involve students in exploring the science and economics behind the production and the impact to Arkansas. The 1st task will explain how natural gas occurs. The 2nd task explains why it is important to Arkansas. The 3rd task allows students to discover the properties of shale and the 4th task explores the steps completed to extract natural gas from the earth through hydraulic fracturing.

There are two assessment options beyond the student information sheets. The students will have the opportunity to ask a geologist a question about the knowledge they have gained and receive a response from a real geologist via email. Students will also complete a persuasive essay about the issues concerning hydraulic fracturing.

Arkansas Standards:

Code:	Standard:
CCSS.ELA-Literacy.CCRA.R.1	Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
CCSS.ELA-Literacy.CCRA.R.7	Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words

CCSS.ELA-Literacy.CCRA.R.8	Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
CCSS.ELA-Literacy.CCRA.R.10	Read and comprehend complex literary and informational texts independently and proficiently.
CCSS.Math.Content.4OA.A.3	Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.
CCSS.Math.Content.4.NBT.A.2	Read and write multi-digit whole numbers using base-ten numerals, number names, and expanded form. Compare two multi-digit numbers based on meanings of the digits in each place, using >, =, and < symbols to record the results of comparisons.
CCSS.Math.Content.4.NBT.A.3	Use place value understanding to round multi-digit whole numbers to any place.
CCSS.Math.Content.4.NBT.B.5	Multiply a whole number of up to four digits by a one-digit whole number, and multiply two two-digit numbers, using strategies based on place value and the properties of operations. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.
CCSS.Math.Content.4.NBT.B.6	Find whole-number quotients and remainders with up to four-digit dividends and one-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.
CCSS.Math.Content.4.MD.A.2	Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.

Science and Engineering Practices	• Asking questions (for science) and defining problems (for engineering) • Constructing explanations (for science) and designing solutions (for engineering) • Engaging in argument from evidence • Obtaining, evaluating, and communicating information
Social Studies/Economics	
Choices	Students shall analyze the costs and benefits of making economic choices.
Resources	Students shall evaluate the use and allocation of *human*, *natural*, and *capital resources*.
Markets	Students shall analyze the exchange of *goods* and *services* and the roles of governments, businesses, and individuals in the *market* place.
Physical and Spatial	Students shall develop an understanding of the physical and spatial characteristics and applications of geography.
Interaction of People and their Environment	Students shall develop an understanding of the interactions between people and their environment.
Science	
Matter: Properties and Changes	Students shall demonstrate and apply knowledge of matter, including properties and changes, using appropriate safety procedures, equipment, and technology.
Earth Systems	Students shall demonstrate and apply knowledge of Earth's structure and properties using appropriate safety procedures, equipment, and technology.
Teacher Excellence and Support System: 1c: Setting instructional outcomes, 1d: Demonstrating knowledge of resources, 1e: Designing coherent instruction, 1f: Designing student assessments, 3b: Using questioning/prompts and discussion, 3c: Engaging students in learning, 3d: Using assessment in instruction.	
Instructional Strategies and Practices: Included in the standards section above.	

Bloom's Level(s):
Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation

Materials and Resources:
The student information sheets and assessments are included at the bottom of the lesson and as a Word document on the web site.

Formative Assessment:
Student information sheets for all 4 tasks, *Ask a Geologist* question and the response from a geologist, and a persuasive essay.

Teaching Notes:
Teachers may decide the grouping of students based on levels of independence and the available technology. Differentiation may include completing tasks as whole group, small teams or as individuals.

Previous knowledge built upon, grouping suggestions, points of interest, technology connections, differentiations, key vocabulary, arrangement of classroom, safety procedures, progression etc…

Student Activity:
Teacher will establish work groups then distribute WebQuest Tasks in print (see **Student Handout**) or electronic format. Students will use the information to build a foundation of knowledge about the natural gas industry in Arkansas and to explore the science and economic impact of the industry on the state. **The printable Web Quest Tasks Handout is included in the Student Handout section and as a separate Word Document on the web site** (arkansasenergyrocks.com).

After students complete WebQuest Tasks, they will complete the assessment opportunities included at the end of the WebQuest handout.

Natural Gas in Arkansas WEB Quest Facilitator Key and Assessment

Task 1: What is Natural Gas?

Using key words and phrases from the questions below, find information on the internet to complete the following questions:

1. What is natural gas?
   Answers will vary but may include some of the following information:

   Natural gas is a fossil fuel which is a combustible, gaseous mixture consisting largely of methane and other simple hydrocarbon compounds, including ethane, propane, butane and pentane. It is usually found in deep underground reservoirs formed by porous sedimentary rocks, especially those yielding petroleum, ...

2. What are the 4 primary gasses that make up natural gas?

Answer: Methane, Ethane, Butane and Propane (other minor gases may also be listed)

3. Name four ways natural gas is used?
   Answers will vary. Possible Answers:
   Transportation, Manufacturing, Heating and Electricity Generation, Consumer products.

Task 2: Why is Natural Gas Production Important to Arkansas?

Using the following suggested key phrases and others selected by the student, explore the internet to complete the questions below:

- Benefit of natural gas
- Economic impact of oil and gas jobs in Arkansas
- Oil and gas jobs and the economy in Arkansas
- Average annual income for Arkansas workers
- Arkansas household income
- Arkansas severance tax revenue

Also refer to:
Revisiting the Economic Impact of the Natural Gas Activity in the Fayetteville Shale: 2008-2012
(https://cber.uark.edu/files/Revisiting_the_Economic_Impact_of_the_Fayetteville_Shale.pdf)

1. Why have the Fayetteville Shale activities and the oil and gas industry been beneficial to the economic growth of Arkansas?
   Answers will vary, but should include some of the following:
   - **Average annual pay in the oil and gas extraction industry** was **$74,555 in 2010**, twice the average pay of all industries in the state. High paying jobs are essential for the economic development of the state because Arkansas consistently ranks in the lowest quintile among all states in terms of annual per capita personal income.
   - **Mineral leases and royalty payments** provide **additional income** to Arkansas residents. These are important sources of income to citizens
   - **Higher average annual pay, additional income received from mineral leases and royalty payments, and other induced impacts result in higher personal incomes, which lead to larger personal expenditures.** As the growth rates of state sales tax collections declined during the recession from the growth rates of 2004 to 2006, additional personal expenditures helped bring sales tax revenues to the state and local governments.
   - **The mining, quarrying, and oil and gas extraction industry had the highest growth rate in payroll employment among all other industries in Arkansas. This industry contains the oil and gas extraction sector and support activities for the mining sector (which, in turn, includes drilling oil and gas wells and support activities for oil and gas operations**

2. According to the latest figures how many employees are working in oil and gas industry establishments in Arkansas? State the year of the statistics that were used for your answer?
   Answer: For 2012, the US Census Bureau reported 10,198 jobs in the Mining, Quarrying, and Oil and Gas Extraction Industry in Arkansas.

   Also refer to: https://cber.uark.edu/files/Revisiting_the_Economic_Impact_of_the_Fayetteville_Shale.pdf

3. What additional activities have been generated in the Fayetteville Shale development that improved the economic conditions in Arkansas
   Answer:
   - **Fayetteville Express Pipeline $1.0 Billion**
   - **Welspun Corporation pipe manufacturing factory $280 million**
   - **Saint-Gobain Group built a new plant in Saline County: $100 million**
   - **American Railcar Industries, Inc. added 1,000 employees to its two plants in Arkansas and one plant in Missouri that build cars for hauling sand used in hydraulic (No dollar amount specified)**

4. What was the increase in the production of natural gas in Fayetteville Shale counties between 2004 and 2011?
   Answer: Production of natural gas in Fayetteville Shale counties increased significantly from 100.6 million cubic feet in 2004 to almost 943.6 billion cubic feet in 2011.

5. How much severance tax revenue did Arkansas collect from natural gas in the most recent year recorded? If natural gas production remains approximately the same, how much total severance tax can be expected for the next 5 years?
   Answer:
   Part 1: To find the most recent statistics, use key phrase: Arkansas Natural Gas Severance Tax; select Statistics; then select most recent recorded taxes.
   Part 2: Multiply the taxes of the most recent year by 5.

Task 3: What is Shale and Where is it Located in Arkansas?

Using key words and phrases selected by the student, explore the internet to find the following:

1. Define shale:
   Answer: Shale is a fine-grained sedimentary rock that forms from the compaction of silt and clay-size mineral particles that are commonly called "mud." This composition places shale in a category of sedimentary rocks known as "mudstones."

2. Explain in detail how sedimentary rocks are formed:

Answer: A river carries, or transports, pieces of broken rock as it flows along. When the river reaches a lake or the sea, its load of transported rocks settles to the bottom. We say that the rocks are deposited. The deposited rocks build up in layers, called sediments. This process is called sedimentation.

The weight of the sediments on top compresses the sediments at the bottom. This is called compaction. The water is squeezed out from between the pieces of rock and crystals of different salts form.

The crystals form a sort of glue that sticks or cements the pieces of rock together. This process is called cementation.

These processes eventually make a type of rock called sedimentary rock. It may take millions of years for sedimentary rocks to form.

3. What is meant by the term **shale gas**?
   Answer: Shale gas is natural gas that is found trapped within shale formations. Shale gas has become an increasingly important source of natural gas in the United States since the start of this century, and interest has spread to potential gas shales in the rest of the world.

4. The Fayetteville Shale is a deposit of sedimentary shale rock formation that stretches across Arkansas. Give a complete physical description of the formation:
   - Location of the deposit
   - Size in square miles
   - Approximate depth
   - Approximate thickness
   - Counties included in the Fayetteville Shale Play

   Answer will vary slightly. Possible answers:
   Location: The Fayetteville shale is located on the Arkansas side of the Arkoma Basin and cuts a swath through the north-central part of the state east to the Mississippi River.

   Size in square miles: 2,838-square miles

   Approximate depth: 1,500 to 6,500 feet

   Approximate thickness: The thickness of the Fayetteville Shale varies from around 50-75 feet in western Arkansas to approximately 300 feet in the eastern Arkoma Basin

   Counties included in the Fayetteville Shale Play:

   Cleburne County AR
   Conway County AR
   Faulkner County AR
   Pope County AR
   Van Buren County AR
   White County AR

Task 4: What is fracturing (fracking)?

Using the key word "fracking," locate a video and other resources to complete the following questions.

1. After watching an animated video of the "fracking "procedure, describe the steps from drilling to completion of a well.
   Possible Answer: First the shaft is drilled several hundred feet into the ground; from there a horizontal hole is drilled into the gas barring rocks. Next the fracking fluid is pumped into the ground using high performance pumps. The mixture penetrates into the rock and produces innumerable tiny cracks. The sand keeps the cracks from closing again. The chemicals perform various tasks, among other things they compress the water, kill off bacteria or dissolve minerals. Next the majority of the fracking fluid is pumped out again, and now the natural gas can be recovered. As soon as the gas source is exhausted the hole is sealed.

2. What is in fracturing fluid?
   Answer: **Ninety percent of fracking fluid is made up of water, and another 9.5 percent is standard sand, according to the American Petrol Institute's Energy Tomorrow project. The remaining 0.5 percent of the fracking fluid is made up of chemicals. The exact formula of the chemical portion is usually a proprietary mixture that is not disclosed.**

3. What are some benefits of horizontal drilling and hydraulic fracturing?
   Answer: Less Surface Area, Fewer Wells, Increased Water Efficiency, Reduced Air Emissions.
   Fracking allows us access to natural deposits of gas that we have not yet been able to get to with our other, traditional methods of extraction. Fracking and horizontal drilling processes allow multiple sources to be tapped from a single bore. Where wells used to be drilled every few hundred feet in clusters over an oil or gas field, today a single well can do the job. As a result, fewer wells use less energy resulting in lower emissions from both drilling and pumping equipment and secondary hydrocarbon releases.

Assessment #1:

After completing this web quest students will work with 4 to 5 other students to compose a question to ask a geologist to extend their knowledge. The group's question must be printed and turned in as an assignment. Using the questions from each group, the class will compose one or two questions to be emailed to:

> USGS Ask A Geologist (https://answers.usgs.gov/)
> (This web address may change over time. You may use key phrase: USGS Ask A Geologist to locate the correct web site.)

Another option is to contact the **Arkansas Geological Survey** (https://www.geology.arkansas.gov/) to request assistance in answering the questions. When students receive answers they will be shared with the class.

Assessment #2:

Students will complete a persuasive essay from the viewpoint of the natural gas industry explaining why Arkansas should continue drilling for natural gas using the current technologies.

Student Handout: A printable copy is available on the web site at
http://www.arkansasenergyrocks.com/educators/lesson-plans-k-8/

Student Worksheet
Natural Gas in Arkansas WEB Quest Tasks and Assessment

Use the back of this sheet or a separate sheet to answer.

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