

2.4.1 NATURAL RESOURCES CASE STUDY: WHAT THE FRACK?

Supplies:

1. YouTube video and projection system
2. Paper copies of documents
3. Check that document set is visible in eLearning (filename: 2-4-1 Fracking notes.pdf)

During class:

1. Engage students in a discussion of the Before You Begin questions to introduce the activity (15-20 min).
 - a. Have students answer in groups on white boards (5 min).
 - b. Discuss responses as a class (10-15 min)
 - i. Students should recall that natural gas is formed when marine microorganisms die and are buried with sediment, subjected to heat and pressure, converted to oil, and boiled to form natural gas.
 - ii. Review the misconception that natural gas and the gasoline in cars are the same; they are different (gasoline is petrol, a liquid; natural gas is methane, a true gas).
 - iii. Students should be aware from the previous activity that natural gas is typically underground, so we have to drill down through the rocks to get to the gas deposits. Ask how far underground we can drill?
 - iv. Risks may be spills, seeps, fire, etc.
 - v. Students probably have varying prior knowledge of fracking. They may have heard the term in news reports. Review that fracking takes place in Michigan.
2. Give students an overview of Part 1 of the Activity
 - a. Students will watch a video to understand how fracking works and why it is necessary.
3. Watch the hydrofracking video together as a class (show on front screen) (5 min)
4. Give additional instructions for completing Part 2 of the activity
 - a. Students are given a scenario in which they are teachers at an elementary school near where a proposed hydrofracking operation is to begin. They are to review the documents provided and write a memo either in favor of or against the operation
 - b. Do not write on the documents. A copy is available in ELearning.
 - c. Do not look at additional sources. Only the information in the documents may be used to make the final decision
 - d. Think carefully about the source of the information – the goal of the activity is to separate the scientific information from opinions and to look for potential bias
 - e. Write the final opinion as a memo
5. Set students loose to work on the activity and write up the Outcome questions (1 hr)
 - a. In Part 1, students can review the video on their computers
 - b. In Part 2
 - i. Document #1 (PetroFrack) is simply factual information about the site. Emphasize that the company would have hired a consulting firm to describe the site and document any potential environmental impacts.
 - ii. Documents #2 (Michigan Green) and #3 (Economic Council) are opinion pieces. Both have exaggerations, some erroneous claims, and are clearly biased. Heather made these up, but don't tell the students.

- iii. Documents #3 (EPA report) and #4 (Watershed Council) are from reputable organizations, albeit those with an environmental protection mandate.
 - iv. Document #5 (Nature commentary) is the only piece from a peer-reviewed journal, although it is an opinion piece that is fair to both sides of the issue.
 - v. Help students to separate out the legitimate advantages and concerns from the wilder ideas!
6. Students may leave when work is submitted and work areas are cleaned up.

Wrap-up group discussion (held at start of next class):

1. Review why fracking is necessary to extract natural gas from shale, because shale has such a low porosity and permeability that the gas will not naturally flow out. The fractures allow the gas to escape.
2. Review the steps in fracking a well
 - a. Drilling
 - i. Drill vertically to the target layer
 - ii. Case the well with steel and concrete so that the drilling does not contaminate the aquifer
 - iii. Drill horizontally along the shale layer
 - iv. Case again, adding more steel and concrete
 - b. Stimulation
 - i. Lower the perforating gun and explode charges to punch holes in the well casing
 - ii. Inject the fracking fluid, which cracks the rock
 - iii. Perforate and inject fluid several more times along the well
 - c. Completion
 - i. Drill out any plugs
 - ii. Allow the fluid to flow back out, collect, and dispose
 - iii. Collect the natural gas as it flows back out the well
3. Review how the model is distinct from actual fracking
 - a. Scale – real wells are MUCH deeper
 - b. Real wells are drilled horizontally
 - c. Fluid does seep back up, but so does gas (no gas in the model)
4. With student input, review the key arguments in favor of fracking
 - a. Fracking has been in use since the 1940s with little environmental impact and is a tightly regulated industry (Michigan has some of the nation's strongest regulations)
 - b. Well construction and actual fracking takes only a few months with a well lifespan of 20-40 years
 - c. Frack fluid is 99.5% sand and water with the rest mostly common household chemicals. Companies voluntarily report the composition of fluids on a website.
 - d. Domestic reserves (shale plays) have ~750 trillion cubic feet of gas and 24 billion barrels of recoverable oil (energy independence, national security, etc.)
 - e. Fracking boosts local economies (creates jobs, pays royalties to landowners, taxes to local governments)
 - f. Natural gas is a cleaner burning, affordable "alternative" fuel
 - g. Water use is high but regulated so that there are no negative impacts to local water sources

- h. Construction of wells (steel casing and cement lining) prevents contamination of ground and surface water when properly done. No link to contaminated water exists.
 - i. Waste frack fluid is either recycled, injected for deep storage, or delivered to wastewater treatment facilities (in Michigan it is injected deep underground)
 - j. Fracking poses no threat to air quality (due to regulation of diesel engines)
5. Review the key arguments against fracking
- a. Fracking has been in use for a long time but the combination of horizontal drilling and pressurized fluids is only ~20 years old
 - b. Industry is poorly regulated (exempt from Safe Drinking Water Act, not required to report composition of frack fluids)
 - c. Frack fluid contains >600 chemicals, about 75% have adverse health effects (and many are known carcinogens, affect the nervous system, immune system, etc.)
 - d. Natural gas is no cleaner than conventional gas (taking into account the CO₂ emissions from diesel engines expended to extract the gas)
 - e. Shale gas has a larger GHG footprint than conventional gas and coal (taking into account gas leakage during extraction, transport, and processing) – methane is a more potent gas than CO₂
 - f. Fracking uses millions of gallons of water per frack and impacts groundwater use
 - g. Gas can seep from the wells and contaminate local ground and surface water
 - h. Treatment of waste frac fluids varies from state to state; many have weak environmental policies and lax regulations
 - i. Risk of oil spills, blowouts, contaminated soil and water, etc. during the drilling process (the actual fracking process is safe, it is the drilling we should worry about)
6. Discuss how students evaluated quality and source of information in the activity (evidence of bias, misleading information, etc.)

Key to Outcome Questions (20 points)

Outcomes Part 1

1. Why is it necessary to fracture shale in order to extract natural gas?

(1 point) Shale has low porosity and permeability so the gas is essentially trapped. Fractures have to be created to let the gas out.

2. Summarize the steps required to drill and hydraulically fracture a well in order to extract natural gas.

(4 points) Answer should include most of the following steps (OK to consolidate them):

- *Drill vertically to the target layer*
- *Case the well with steel and concrete so that the drilling does not contaminate the aquifer*
- *Drill horizontally along the shale layer*
- *Case again, adding more steel and concrete*
- *Lower the perforating gun and explode charges to punch holes in the well casing*
- *Inject the fracking fluid, which cracks the rock*
- *Perforate and inject fluid several more times along the well*
- *Drill out any plugs*

- Allow the fluid to flow back out, collect, and dispose
- Collect the natural gas as it flows back out the well

3. What is fracking fluid (called “stimulation fluid” in the video) composed of? What is the purpose of the sand added to the fracking fluid? What is the purpose of the chemical additives?

(2 points) Fracking fluid is mostly water and sand plus chemical additives. The sand is needed to hold the fractures open once they are created. The chemicals are for lubrication, to keep bacteria from growing, and to carry the sand.

4. What is the source of this video? Why is knowing the source of the video important?

(1 point) Marathon Oil produced the video – bias, anyone?

Outcomes Part 2

1. Summarize 5 important points in favor of supporting the hydrofracking operation.

(2 points) Response should consider some of the following (other reasonable answers from the assignment are also acceptable):

- *There are no environmentally sensitive species, landforms, nearby people, etc. at the site. It is located on vacant land away from water sources. So there is minimal environmental impact.*
- *The operation can bring economic development (jobs, tax revenue) to a struggling town.*
- *Fracking has been in use since the 1940s with little environmental impact and is a tightly regulated industry (Michigan has some of the nation’s strongest regulations)*
- *Natural gas is a cleaner burning, affordable “alternative” fuel*
- *Construction of wells (steel casing and cement lining) prevents contamination of ground and surface water when properly done. No link to contaminated water exists.*
- *Waste frack fluid is will be stored in tanks and injected underground (MI regulation)*

2. What scientific evidence supports each of these points in favor of the operation? Cite the source (website, letter, paper, etc.) of each piece of evidence.

(2 points) For each point, students should elaborate on where the evidence came from. Pay attention to whether they are citing the opinion pieces or the more reputable sources of evidence.

3. Summarize the 5 key points against supporting the proposed operation.

(2 points) Response should consider some of the following (other reasonable answers from the assignment are also acceptable):

- *Frack fluid contains >600 chemicals, about 75% have adverse health effects (and many are known carcinogens, affect the nervous system, immune system, etc.)*
- *Natural gas is no cleaner than conventional gas, and extracting natural gas takes more energy than conventional drilling*
- *Methane is a more potent greenhouse gas, escaping gas contributes to global warming*
- *Fracking uses millions of gallons of water per frack and impacts groundwater use*
- *Gas can seep from the wells and contaminate local ground and surface water*
- *Risk of oil spills, blowouts, contaminated soil and water, etc. during the drilling process*

4. What scientific evidence supports each of these arguments against hydrofracking? Cite the source (website, letter, paper, etc.) of each piece of evidence.

(2 points) For each point, students should elaborate on where the evidence came from. Pay attention to whether they are citing the opinion pieces or the more reputable sources of evidence.

5. Write a short memo (150-200 words) addressed to the school board chairperson that states the final recommendation of your teacher team. Be sure to note the evidence and arguments that support your position.

(4 points) For a response in memo form that lays out a clear argument supported by evidence.

2.4 CASE STUDY REFLECTION: HOMEWORK (20 points)

Individually answer the following questions that reflect on the Fracking activity. The individual response can be done in class (time permitting) or as homework. A separate Dropbox folder will be available for your responses – create and submit a Word document (like we do in class). These responses will only be reviewed by your instructor. Grading will be based on evidence of careful reflection on the activity and thoughtful responses.

1. What would be your personal recommendation to the school board (note you might agree or disagree with what your group submitted)? How did you reach this recommendation?

(8 pts) Any response is fine as long as it is clearly explained and justified.

2. Look carefully at the source of each of the documents. Is there any evidence of bias in the documents? Does knowing the source of the information change how you view that information?

(8 pts) There is definitely bias in nearly all of the documents. Considering the source of information is important in making judgments about the quality of information. Interest groups often have specific agendas and will present information in a way that makes the strongest possible case for their position (and attempts to undermine any other position). This has to be considered in making judgments.

3. Three Next Generation Science Standards (national guidelines for K-12 science education) that pertain to this activity are:

- **4th Grade (4-ESS3-1).** Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
- **5th Grade (5-ESS3-1).** Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment.
- **Middle School (MS-ESS3-4).** The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.

Choose one of these standards, and explain how this class activity applies to it.

(4 pts) Any explanation is reasonable.

