Unit Plan for Chemistry with a Literacy Approach

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Introduction

The unit described in this plan is intended for a tenth grade chemistry course. The students who will participate in the unit attend a mid-sized urban high school in Grand Rapids, MI. The school as a whole has an enrollment just below 600 students, with an ethnic composition of roughly 46% Hispanic/Latino, 43% African-American, and 10% Caucasian students (Search for Public Schools, 2010). The population of the school consists of predominantly low-income students, with 90% receiving free or reduced lunch (Central High School, 2011). The school uses a traditional schedule with six class periods per day, each lasting fifty-five minutes. Most of the lessons in the unit will span multiple class periods, with one lesson being completed in a single period.

For this unit, two different classroom settings will be used. The first setting is a traditional classroom. In this classroom, there are 40 desks arranged into ten groups. Each group consists of 4 desks that face each other to facilitate discussion between students. The second setting is a computer lab with 40 desktop computers situated in eight forward facing rows. The students will accomplish much of their discussion and collaboration in the traditional classroom, and will complete individual work and research in the computer lab.

The unit in which the students will participate focuses on petroleum as a source of fuel, and alternative sources of energy. In brief, students will learn how fuels work, discover and learn about alternative sources of energy and how to compare them, and choose which type of alternative energy would be the best option if gasoline had to be replaced.

One of the main literacy goals of the unit is for students to build upon their out-of-school digital literacies, and apply these skills to the context related tasks within the unit. This goal was shaped by multiple influences. First, Alvermann (2001) writes about the engaging nature of school activities that extend and elaborate on the literacy practices that students already possess and value. Another idea that factored into this goal is that the authenticity of adolescents' education is at risk when teachers do not capitalize on the way they read, write, create, and think in a digital environment (Hinchman & Sheridan-Thomas, 2008). The final influence came from the students themselves. In an inquiry into their learning and classroom practices, students overwhelmingly supported and requested the use of social networking and other digital literacies in learning activities. This unit presents multiple opportunities for students to not only apply, but also to advance their digital literacies within specific tasks.

In addition to applying out-of-school digital literacies, a second goal for the unit is to promote literacy through inquiry. By designing the unit around an essential question and a clearly defined final project, students will be more engaged in the literacy tasks of the unit. Beyond better engagement in reading and writing, an inquiry approach also promotes deeper meaning and a more sophisticated understanding of content. As evidenced by the lessons below, the approach to planning this unit was heavily influenced by Wilhelm's book, *Engaging Readers and Writers With Inquiry* (2007).

Curriculum Map

Instructional context: Petroleum as an Energy Source/Alternative Fuels

Timeline: 11 class periods, 55 minutes each

Placement context: Chemistry, Grade 10

Essential Questions/ Overall Goals	**Content**	**Skills**	**Learning/Teaching Strategies**	**Cumulative Assessment**
Primary Goals:	Using fuel is a process of energy conversion	Students will use their out-of-school digital	Class discussions in the	Students will draft a letter or create a multimedia

1. Students will apply their out-of-school digital literacies to address a current problem faced by the scientific community and society in general. 2. Students will understand fuels as sources of energy, and will be able to provide evidence and reasoning for selecting a proper replacement for gasoline Related Essential Question: If we had to replace gasoline with another energy source, what would be the best alternative?	(Michigan Department of Education, 2006). Combustion of fuel is an exothermic reaction (Michigan Department of Education, 2006). The amount of energy provided by a fuel can be measured using heat of combustion. Fuels can be compared in numerous ways, including heat of combustion, environmental impact, availability, cost, and sustainability	literacies related to social networking: • As a way of gaining perspective on the problem of finding an alternative to gasoline. • To share and help them reflect on their decision for the most suitable alternative and the scientific explanation of their choice. Students will form scientific conclusions and explanations that result from careful analysis of empirical evidence and the use of logical reasoning (Michigan Department of Education, 2006). Students will understand that through science they can produce critical insights on societal problems from a personal and local scale to a global scale (Michigan Department of Education, 2006).	following talk formats: • Teacher led whole-class • Teacher guided small group • Think/Pair/Share Textbook reading accompanied by the use of Wilhelm's "What?/So What?/Now what?" strategy Prompts for before, during, and after reading Analysis of a controversial statement Entrance and exit tickets Heuristic questions after reading	presentation to be shown to their representatives in local, state, and federal government. This letter or presentation will include elements of a scientific explanation (claim, evidence, and reasoning), and will be an attempt to persuade policymakers to increase funding for research, development, and/or application of the alternative energy source they view as the best option.

Daily Lesson Plans

LESSON 1 (Two class periods):

This lesson serves as the opening activity for the unit. It is designed as an engagement activity that will activate the prior knowledge of the students, and uncover areas of need in their learning. Additionally, students will begin to connect their areas of need with pathways that will allow them to obtain the required knowledge and understanding. The activities within this lesson incorporate aspects of both frontloading, and gateway activities (Wilhelm, 2007).

Objectives:

Students will:

- begin thinking about how they interact with petroleum and gasoline
- confront the problem that petroleum is a finite resource that will eventually be depleted
- begin to address the essential question for the unit and the final project which addresses the essential question
- generate sub-questions related to the essential question
- use their social networks as sources of background knowledge and to generate ideas for the final project
- reflect on and discuss the information, ideas, and points of view they gained as a result of this lesson

Lesson Plan:

- Step 1: To activate and expose prior knowledge, and to connect students to the material, I will pose the warm-up question, “What do you know about gasoline?” A whole-class discussion will follow.

- Step 2: For further engagement, and to establish the problem, I will show a video clip that details petroleum as a finite, non-renewable resource. Again, a brief discussion will ensue where I will ask the students to reflect on the video, and share their thoughts with the class.
- Step 3: With the realization that one day we will exhaust our supply of petroleum, I will ask the students, "If we had to replace gasoline with another source of energy, what would be the best alternative?" This will serve as the essential question for the unit, to which all learning will be connected (Wilhelm, 2007).
- Step 4: In accordance with the approach outlined by Wilhelm (2007), I will introduce the final project for the unit at this time. The task for this project will be to draft a persuasive essay or create a multimedia presentation that both addresses the essential question and convinces policymakers to fund further research and development for the most promising alternative energy source. It is important to introduce the final project here, at the beginning of the unit, because the students must know that every action they take should result in gathering knowledge or producing an artifact that is in conscious preparation for the final critical-inquiry activity (Wilhelm, 2007)
- Step 5: As a way to begin addressing the essential question, I will explain to the students that they will be asking their social networks for information, ideas, and opinions related to this problem. Through use of the "think-pair-share" discussion format (think individually for 5 minutes, discuss with a partner for 5 minutes, share ideas with the rest of the class), the students will generate sample questions to ask, but ultimately individual students will have freedom to ask any question, in any terminology they choose.

- Step 6: The students will move to the computer lab where they will pose the questions they have chosen to their social networks. The minority of students who do not normally participate in a social network will have two choices at this stage. Either they will pair up and apprentice with a student who is a member of a social network, or they can gather information and ideas from a general internet search, or through direct contact with experts in the field, or others with professional knowledge of energy and fuels. Students who choose the second option may be able to provide valuable insight for comparing the benefits and drawbacks of both methods of research. This activity will complete the first day of the lesson.
- Step 7: At the beginning of the second day, students will collect and analyze the responses they received to their questions. In order to scaffold the evaluation of responses, I will provide the students with an evaluation sheet that prompts them to answer the following questions (see Appendix A):
    - Which responses did you find most helpful? Why?
    - Which responses did you find least helpful? Why?
    - Which responses reaffirmed your own thinking? Why?
    - What new insights did you gain as a result of this activity?
    - Which responses provided information or ideas that you would like to explore further? Why?

  After the students have completed their evaluation sheets, they will discuss in small groups and share with the class the ideas, information, insights, and opinions they found most beneficial in addressing the essential question and final project. I understand that some of my students will receive limited responses, or none at all, but my hope is that enough information will be conveyed to make the class discussions worthwhile and productive.

- Step 7: As a final reflection for this activity, and a gateway into the next, I will display the following prompts on the overhead, and have the students respond to them individually: "What do I think, what do I know, what do I need to know, and where can I go from here?" Responses will once again be shared in a whole-class discussion. During this discussion, I will chart the shared information as a way of combining and connecting all of the responses.

  In addition to putting everything together, the final reflection activity will provide students with an artifact that will be useful as they move toward more direct research in pursuit of solutions to the problem of finding an alternative to gasoline (Wilhelm, 2007). Furthermore, the reflection questions will be used to summatively assess the effectiveness of the application of students' digital literacies. The questions will also serve as a formative assessment of the progress students have made in their ability to respond to the essential question.

Homework:

Assignment 1. Following this lesson, the students will be given an entrance ticket that is to be completed before the next day of class. This entrance ticket will be described in Lesson 2.

Assignment 2. I will instruct the students that in the coming days they will be researching different forms of energy. I will ask them to reflect on their own knowledge and the responses they received from this activity to select their top three choices they wish to explore. This assignment will be due at the end of the second lesson so that students will have time to explore their options, and perform any preliminary research that may assist them in making a decision. I will make it explicit that their final decision for the energy source of the future does not necessarily have to be one on which they performed research. However, if students already favor one type of energy, it would be wise to select it their top three.

LESSON 2 (One class period):

In this lesson, students will read a passage in their chemistry textbooks to gain perspective on how fuels function. Before reading, an entrance ticket strategy will be used to connect this topic to the background knowledge of the students (Wilhelm, 2007). The lesson will also promote interpretive connections within the text by prompting the students to consider several questions while they read (Wilhelm, 2007). Finally, after the students read the passage they will complete an exit ticket to reflect on what they have read, and transfer their learning to a new application (Wilhelm, 2007). Each stage in the lesson will incorporate discussion as a way to share understandings and insights, and to express the thinking and learning of the students.

Objectives:

Students will:

- Relate their prior knowledge to a new topic
- Interpret and make connections that link topics in a textbook passage
- Understand how and where to apply information gained through reading

- Understand that fuels possess energy in one form, and that when a fuel is burned, the energy is converted into another form.
- Understand that the amount of energy a fuel provides can be measured using the heat of combustion of that fuel

Lesson Plan:

- Step 1: As a way to connect students' prior knowledge, including any background information they received as a result of the previous lesson, to the topic of this lesson, I will have the students complete an entrance ticket (See Appendix B) before the beginning of this class (Wilhelm, 2007). When these tickets are distributed, I will explain that the topics referred to on the ticket are forms of energy, energy conversion, and energy measurement. The specific questions that the students will be asked are:
    - What do you already know about these topics?
    - Why might learning about these topics be important?
    - How do you think we will be able to use what we have learned/will learn?

  These questions will activate prior knowledge, create a need for learning the content, and help students begin to see how and where the information can be applied. At the beginning of this lesson, we will discuss the entrance tickets in a whole-class setting

- Step 2: I will assign the class a textbook passage to read (See Appendix C) that describes how fuels contain energy in the form of chemical potential energy, and that when the fuel is burned, the potential energy is converted into various other forms, including mechanical energy, heat energy, and light energy. The text also explains that the amount of energy a fuel provides when burned can be measured by heat of combustion. Before assigning this reading, I will show the following questions on the overhead and instruct the students to think about and jot down notes related to the questions while they read:

- How does the flow of energy relate to forms of energy?
- How does heat of combustion relate to the flow of energy and/or forms of energy?
- How does the information in this passage relate to the essential question?

Although initially the students will contemplate the questions individually, their primary purpose is that they will be used as prompts for discussion. Through the discussion of these questions students will make interpretive connections between ideas and applications (Wilhelm, 2007). The talk format for this discussion will start with a small group silent discussion thread, which will be followed by a verbal discussion within the same groups. The importance of the silent discussion thread is that it forces each member of the group to contribute. If students know their ideas and understandings will be shared with a group, they are more likely to be engaged during the reading. The thread will follow the guidelines detailed by Wilhelm (2007):

1. Each member in a group of three randomly assigned students will receive a sheet with one of the three discussion questions at the top (See Appendices D, E, and F).

2. Each member of the group will write a response to his or her question.

3. When instructed, each student will pass his or her sheet to the person on the left.

4. The students will then read the question and the response on the sheet.

5. Each student will add new information or a new insight to the answer already on the sheet.

6. When instructed, the sheets will again be passed to the left, and the students will repeat step 5.

7. The third student to add to each sheet will summarize all of the information, and a verbal discussion of each sheet will take place.

- Step 3: In order for students to reflect on this lesson and to orient their thinking toward the future, the students will complete exit tickets before they leave class for the day (Wilhelm, 2007). For this activity, I will distribute and instruct students to write on a note card an answer to the question, "How will I use something I learned today on the final project?" This activity will help the students transfer their learning, and apply it to the essential question and final project for the unit. It will also be a way for me to learn from the learning of my students, and will provide an opportunity to assess gaps in their understanding, confusions, and desires for future learning (Wilhelm, 2007). I will lead a whole-class discussion of the exit tickets at the beginning of the next class period.

Homework:

For homework, I will have the students invite at least one professional person or organization in a chemistry related field, and at least one official from local, state, or federal government into their social networks (I.E. to "friend" that person or organization on Facebook). I will give the students some suggestions such as names of specific scientists, city mayor George Heartwell, State Rep. Roy Schmidt, U.S. Senator Debbie Stabenow, The American Chemical Society, Pfizer, and many more.

This assignment does not link to the previous lesson, but will be an important part of the final project—details of how it will be used will be given then. The assignment will be given now to allow students time to decide who they want to invite, and to give enough time for a response.

Students who are not members of a social network can choose to join one at this time, contact these people or organizations directly, or they can serve as a sort of control group when comparing how the use of social networking influenced the outcome of the final project.

LESSON 3 (Three class periods):

In this lesson, students will explore options for alternative energy sources to gasoline. The lesson will begin with students analyzing and responding to a controversial statement about gasoline and alternative energies. This is intended to invite students to actively engage with the content of the lesson (Wilhelm, 2007). Following this, students will perform research on various forms of alternative energy in order to make a decision on which they feel is the most promising option for the future. The students will select forms of energy to research based on the inquiries they made and the responses they received in the initial lesson of this unit. The research will be done individually, but students will discuss their findings in groups when they have finished. I will select the student groups, so that each will include members who researched a variety of alternatives.

Objectives:

Students will:

- Take a stance on whether alternative energy is worth pursuing.
- Become "experts" of at least two types of energy by focusing research on those alternatives.
- Share their research findings with members of a group who performed different research.
- Make a decision about the type of energy that should be used in the future.
- Decide if they have sufficient information to support their claim, or if there is a need to perform further research.

Lesson Plan:

- Step 1: The first activity of this lesson will be a discussion of the exit tickets from the previous lesson. I will address confusion and gaps in understanding by having students who produced exceptional responses discuss their answers. I will use a mirroring technique, reflecting back what the speaker has said so that the he or she is forced to elaborate on his or her statement, bringing about new connections and building deeper meaning (Wilhelm, 2007). As a result of this final reflection and the previous activity as a whole, students will understand how gasoline functions as a fuel, and will be prepared to address the problem of finding an alternative.
- Step 2: To promote active engagement in researching alternative energy sources, I will ask the students to think about and respond to following controversial statement (Wilhelm, 2007):

  Opponents of alternative energy argue the following points:

  - *There is enough gasoline to support our present needs.*
  - *Alternative energies are expensive and will likely harm our economy.*

- *The future will bring new discoveries and advancements in technology, so it's possible that a suitable alternative to gasoline has not been discovered yet.*

They argue that because of these circumstances, we should wait to address this issue.

I will give the students a few minutes to ponder the statement silently, and we will then discuss it as a class. The importance of this activity is that it gives the students something to argue against. If the students can support using an alternative energy, while at the same time refuting the ideas of opponents, they will have a much more credible argument. This gives the students an area on which to focus during their research.

It is possible that some students will agree with the statement. This stance will be completely accepted, but I will remind any students who choose this route that they still must support their claim with evidence and reasoning. In that way, these students will be performing the same type of research as the others. Even if students contend that there no need to replace gasoline, they will still accomplish the goals of the unit.

- Step 3: Using the second homework assignment given at the end of Lesson 1, I will assign the students two types of energy on which to perform research. I will make every effort to allow students to explore their primary choices, but in order to increase variety, it may be necessary to present different options to some students. If a student is not assigned one of his or her top three choices, and does not wish to pursue that form of energy, I will have a personal conversation with that student and attempt to resolve the conflict.

In addition to assigning research topics, I will also place the students in groups based on those topics. Each group will include members who researched different types of energy. The purpose of the groups is to promote discussion of various sources of energy once the research has been completed.

- Step 4: In the computer lab, the students will begin researching their chosen energy sources. I will direct them to a website I created that provides students with guiding questions for their research, as well as links to websites where they may begin their explorations (See Appendix G). (This website can be found at http://sites.google.com/site/syrekn). Some of these guiding questions and links were adapted from an existing webquest for examining alternative energy (Murphy, n.d.). Students will be instructed to take electronic notes (MS Word, Google Docs, etc.) related to the guiding questions. When the research is complete, students will upload the notes to a group wiki (See Appendix H) so that all group members can use them as artifacts on the final project. (For an example of the wiki template, visit http://syreksclassgroup1.wikispaces.com/). I will make it clear that the links I provide are places to start, but that other resources may be needed to gather more information. Additionally, if students wish to start their research elsewhere, they will be free to do so. I will remind them, however, that they should still keep the guiding questions in mind when performing their research.
- Step 5: When students have concluded their research, they will meet in their groups to discuss findings and share information. The discussion will begin with a round-robin sharing of information related to the guiding questions. Following this, the group will

consider and respond to the following critical inquiry prompts as they relate to the individual research and round-robin discussion (Wilhelm, 2007):

(Questions will be written on the overhead)

- Describe something you know/understand/can do better as a result of this lesson.
- What more do you need to know about this topic/these topics?
- How could this research and discussion help you address the problem of finding an alternative for gasoline?

Homework:

To reflect on this lesson and to move forward toward the final project, the students will make a preliminary choice of an alternative energy source to replace gasoline. In addition, they will be required to write at least two things that justify their choice, and at least one question they have about that choice, or something they still need to need to know about it.

LESSON 4 (Five class periods):

This lesson is designed as the final project and assessment for the unit. Students will use what they have learned throughout the unit to urge legislators for more funding in support of a type of alternative energy. They will do this by writing a letter or creating a multimedia presentation that states their claim as to what energy source we should be pursuing, provides evidence for their choice, and gives reasoning that justifies their evidence. Students will peer evaluate each others' projects, and they will also be posted on students' social network to be viewed and evaluated by the community.

Objectives:

Students will:

- Make and justify a decision about the future energy source for our civilization
- Have their choice, and the support for that choice evaluated by peers and members of the community
- Be assessed on the learning goals of the unit

Lesson Plan:

- Step 1: At the beginning of the lesson, I will distribute and describe the detailed assignment sheet to the students (See Appendix I).
- Step 2: For the previous homework assignment, students made a decision about what source of energy they feel would be the best replacement for gasoline. In the first day of this lesson, they will perform any research that still needs to be completed. I will verbally communicate to the students that this research may involve gathering data that supports their choice, disproves the notion that alternative energy is not necessary, or argues against the forms of alternative energy they did not select. Once their research is complete, students will begin planning their projects. To support and scaffold this process, I will provide the students with a planning guide for a persuasive letter or presentation (See Appendix J). This planning guide is a modified version of a persuasive letter outline originally developed by a teacher at Point Loma High School in San Diego (Newman, 2009).

- Step 3: Once a plan is in place, the students will write their letters or create their multimedia presentations. They will be given two class periods to complete this process.
- Step 4: When the projects are complete, a modified version of a gallery walk using social networks will be incorporated (Wilhelm, 2007). The students will post their projects in a premade discussion forum and comment on the projects of others (See Appendix K). I will arrange the students into pairs, and instruct them to make at least three substantive comments that are directly related to the assignment rubric on the project of their partner. By doing this, the students will be made accountable for responding to one another, and it will also provide feedback that may force students to make changes to their projects.
- Step 5: As another way to gather feedback, the students will post their projects on their social networks. As a homework assignment for an earlier lesson, students invited members of the scientific and civic communities to join their personal network. The students will be instructed to send a private message to those people or organizations, asking them to review their projects and to respond with their thoughts and opinions. To allow time for responses, and for the students to reflect on and make changes based on that feedback, the projects will be due one week from the date of this activity. This reflection and editing will be done outside of class as a homework assignment. The final projects will be submitted to me by email.
- Step 6: After the projects have been formally submitted, the students will complete a final reflection of the unit (See Appendix L). I will ask them how their thinking and understanding of the content has changed, and how social networking impacted their

learning. This will give me personal feedback that I can use to make changes and improvements to the unit.

Homework:

The students will complete revisions and modifications to their final projects in response to the feedback they received from their partners, as well as their social networks.

Reflection

The process of planning this unit, from the basic outline to the fine details, involved a variety of ideas and strategies. The overall design of the unit followed Wilhelm's (2007) approach to inquiry. An essential question is used to engage and provide a focus for the students, while the final project is an application of their learning. The activities and lessons were deliberately designed as pathways that will allow students to uncover the necessary information and build critical understandings. The inquiry approach to this unit promotes comprehension and application of the content in ways that would not be possible using a traditional transmission model of teaching.

Like the overall unit design, many of the discussions in the individual lessons were influenced by Wilhelm as well. In planning the unit, a variety of small group and whole class discussion formats were used. The formats used for small group discussion allow students to generate, explore, and elaborate on ideas, make interpretive connections, and reflect on their thinking and understanding in a personal way. Whole class discussions, in turn, provide a place for broad sharing, socializing intelligence, and consensus building. Together the forms of discussion make the unit more student-centered, and allow students to purposefully interact with each other and the material, and to share their understanding and insights. Within these talk formats several discussion strategies were included in the unit plan. Entrance tickets were used to engage students and activate prior knowledge. Exit tickets were included for reflection and to address misunderstandings. To invite active engagement with the content, students analyze a controversial question. And a digital gallery walk was used to facilitate peer evaluation of students' work.

My own teaching experience influenced other aspects of the unit. I have seen engagement increase when students are given choices and freedom of learning. Because of this, students are allowed to choose their research topics. This will give the research much more personal meaning than if it was arbitrarily assigned. I also understand that some activities and processes need to be scaffolded so as not to overwhelm students. This approach was used by providing the students with guiding questions for their research, and a planning guide for their final projects.

Part of planning this unit also involved the development of learning and literacy goals. Like the strategies and approach to the unit, the goals also had multiple influences. I wanted to be sure the unit addressed specific content expectations, so I relied on the Michigan Department of Education for these. The goal of applying students' out-of-school digital literacies to solving the problem of replacing gasoline, however, came about as a way to provide students with an engaging and authentic learning experience (Alvermann, 2001; Hinchman & Sheridan-Thomas, 2008). Moreover, I was also responding to the needs and desires of my students, who directly requested the use of social networks in class activities.

Combined, all of these influences allowed me to carefully piece together a cohesive inquiry unit. Furthermore, they provided the basis for a unit that is engaging, forces students to be active participants in their learning, and addresses a relevant issue. As a result of participating in this unit, students will not only learn science, they will become more literate, and will therefore be more successful lifelong learners.

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Appendix A—Evaluation Sheet

Name:______________________________

Evaluating the use of social networks as resources for chemistry class

Which responses did you find most helpful? Why?

Which responses did you find least helpful? Why?

Which responses reaffirmed your own thinking? Why?

What new insights did you gain as a result of this activity?

Which responses provided information or ideas that you would like to explore further? Why?

Appendix B—Entrance Ticket

Entrance Ticket Name:______________________________

- What do you already know about these topics?

- Why might learning about these topics be important?

- How do you think we will be able to use what we have learned/will learn?

Appendix C—Textbook Passage

B.1 ENERGY AND FOSSIL FUELS

Fossil fuels are believed to originate from biomolecules of toric plants and animals. See Figure 3.23. The energy released burning these fuels represents energy originally captured from light by prehistoric green plants during photosynthesis. Thus, **fuels**—petroleum, natural gas, and coal—can be thought of as of buried sunshine.

Most evidence indicates that fossil fuels originated from living matter in ancient seas some 500 million years ago. These species died and eventually became covered with sediments. Pressure, heat, and microbes converted what was once living matter into petroleum, which became trapped in porous rocks. It is likely that some petroleum is still being formed from sediments of dead matter. However, such a process is far too slow to consider petroleum a renewable resource.

Fossil-fuel energy is comparable in some ways to the energy stored in a wind-up toy race car. The "winding-up" energy that was originally supplied tightened a spring in the toy. Most of that energy, stored within the coiled spring, is a form of **potential energy**, which is energy of position (or condition). As the car moves, the spring unwinds, providing energy to the moving parts. Energy related to motion is called **kinetic energy**. Thus, the movement of the car is based on converting potential energy into kinetic energy. Eventually, the toy "winds down" to a lower-energy, more stable state and stops.

In a similar manner, **chemical energy**, which is another form of potential energy, is stored within bonds in chemical compounds. When an energy-releasing chemical reaction takes place (such as when fuel burns), bonds break and reactant atoms reorganize to form new bonds. The process yields products with different and more stable bonding arrangements of their atoms. That is, the products have less potential energy (chemical energy) than did the original reactants. Some of the energy stored in the reactants has been released in the form of heat and light.

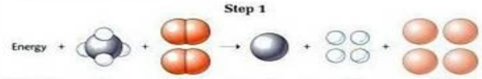
The combustion, or burning, of methane (CH_4) gas illustrates such an energy-releasing reaction. It can be summarized this way:

CH_4 (Methane gas) + $2\ O_2$ (Oxygen gas) ⟶ CO_2 (Carbon dioxide gas) + $2\ H_2O$ (Water) + Energy

The reaction releases considerable **thermal energy** (heat). In fact, laboratory burner flames are based primarily on that reaction—conducted, of course, under very controlled conditions. To gain a better understanding of the energy involved, just imagine that the reaction takes place in two simple steps: One step involves bond breaking and one step involves bond making.

In the first step, suppose that all the chemical bonds in one CH_4 molecule and two O_2 molecules are broken. The result of this bond-breaking step is that separated atoms of carbon, hydrogen, and oxygen are produced. All such bond-breaking steps are energy-requiring processes, or **endothermic** changes. In an endothermic change, energy must be added to "pull apart" the atoms in each molecule. Thus, energy appears as a *reactant* in Step 1, as shown in the following chemical equation:

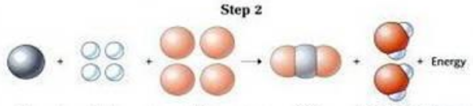
Step 1



Energy + CH_4 + $2\ O_2$ ⟶ C + 4 H + 4 O

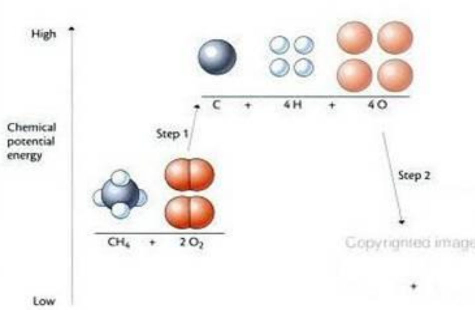
To complete the methane-burning reaction, suppose that the separated atoms now join to form the new bonds needed to make the product molecules: one CO_2 molecule and two H_2O molecules. The formation of chemical bonds is an energy-releasing process, or an **exothermic** change. Because energy is given off, it appears as a *product* in Step 2, as shown in the following chemical equation:

Step 2



C + 4 H + 4 O ⟶ CO_2 + $2\ H_2O$ + Energy

When methane burns, the energy released in forming carbon–oxygen bonds in CO_2 and hydrogen–oxygen bonds in H_2O is greater than the energy used to break the carbon–hydrogen bonds in CH_4 and the oxygen–oxygen bond in O_2. That is why this overall chemical change is exothermic. The complete energy "accounting summary" for burning methane is shown in Figure 3.24.



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Whether an overall chemical reaction is exothermic or endothermic depends on how much energy is added (endothermic process) in bond breaking and how much energy is given off (exothermic process) in bond making. If more energy is given off than is added, the overall change is exothermic. However, if more energy is added than is given off, the overall change is endothermic.

Copyrighted image

Figure 3.25 *Bicycling is an example of continuous conversions between potential and kinetic energy.*

In general, if a process converts potential energy into kinetic energy, then the reverse process converts kinetic energy back to potential energy. For example if you wind the spring of a model race car, you are converting your energy of motion (winding) into energy stored in the spring. A biker or a skateboarder uses the transformation of potential energy into kinetic energy to complete jumps and other tricks (Figure 3.25).

Likewise, if a particular chemical reaction is exothermic (releasing thermal energy), then the reverse reaction is endothermic (converting thermal energy into potential energy). For example, burning hydrogen gas—involving the formation of water—is exothermic. The energy released by the formation of H—O bonds in water is greater than that required to break H_2 and O_2 bonds:

$$2\ H_2 + O_2 \longrightarrow 2\ H_2O + \text{Energy}$$

Therefore, the separation of water into its elements—the reverse reaction—must be endothermic, equal in energy used to that released when water is formed from gaseous H_2 and O_2. Electrical energy is expended and is converted into potential energy that is stored, again, in chemical bonds. See Figure 3.26.

$$\text{Energy} + 2\ H_2O \longrightarrow 2\ H_2 + O_2$$

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Figure 3.26 *An electric current provides energy to decompose water, producing hydrogen (right test tube) and oxygen (left test tube) gas. This process is referred to as the "electrolysis" of water. As follows from the formula of water (H_2O), hydrogen and oxygen gas are produced in a 2 to 1 ratio.*

B.2 ENERGY CONVERSION

Scientists and engineers have increased the usefulness of energy released from burning fuels through devices that convert thermal energy into other forms of energy. In fact, much of the energy you use daily goes through several conversions before it reaches you.

Consider the energy-conversion steps involved in the operation of a hair dryer, illustrated in Figure 3.27. What detailed, step-by-step "energy story" can you devise using these illustrations?

You probably noted that in the first step, stored chemical energy (potential energy) in a fossil fuel, Figure 3.27(a), is released in a power-plant furnace, producing thermal (heat) energy, as shown in Figure 3.27(b). The thermal energy then converts water in the boiler to steam that spins the turbines (mechanical energy), generating electrical energy as shown in Figure 3.27(c). Thus, the power plant converts thermal energy produced in the furnace to mechanical energy, which is a form of kinetic energy, in the turbines. It is then converted to electrical energy, as shown in Figure 3.27(d). When electricity reaches the hair dryer, it is converted back to thermal energy to dry your hair, and it is also converted to mechanical energy, Figure 3.27(e), as a small fan blade spins to blow the hot air. Some sound energy is also produced, as any hair-dryer user knows!

Despite all the changes involved, no energy is consumed or "used up" in any of these steps. The form of energy just changes from *chemical* to *thermal* to *mechanical* to *electrical*. This concept is summarized by the **law of conservation of energy**, which states that energy is neither created nor destroyed in any mechanical, physical, or chemical processes.

B.6 COMBUSTION

Introduction

You strike a match and a hot, yellow flame appears. If you bring the flame close to a candlewick, the candle ignites and burns (Figure 3.30). These events are so commonplace that you probably do not think about the complex chemical reactions at work.

Candle burning involves chemical reactions of the wax, which is composed of long-chain alkanes, with oxygen gas at elevated temperatures. Although many chemical reactions are involved in burning (or *combustion*), chemists simplify the process by usually focusing on the overall changes. For example, the complete burning of one component of candle wax, $C_{25}H_{52}$, can be summarized this way:

$$\underset{\text{Paraffin wax (alkane)}}{C_{25}H_{52}(s)} + \underset{\text{Oxygen gas}}{38\ O_2(g)} \longrightarrow \underset{\text{Carbon dioxide gas}}{25\ CO_2(g)} + \underset{\text{Water vapor}}{26\ H_2O(g)} + \text{Energy}$$

As you already know, a burning candle gives off energy—the reaction is exothermic. Thus, less energy must be stored in the product molecules (in the carbon-to-oxygen bonds of carbon dioxide gas and the hydrogen-to-oxygen bonds of water vapor) than was originally stored in the reactant molecules (in the carbon-to-hydrogen bonds of wax and the oxygen-to-oxygen bonds of oxygen gas).

Fuels provide thermal energy as they burn. But how much energy is released? How can we measure the quantity of released energy? In

Hydrocarbon	Formula	Heat of Combustion (kJ/g)	Molar Heat of Combustion (kJ/mol)
Methane	CH_4	55.6	890
Ethane	C_2H_6	52.0	1560
Propane	C_3H_8	50.0	2200
Butane	C_4H_{10}	49.3	2859
Pentane	C_5H_{12}	48.8	3510
Hexane	C_6H_{14}	48.2	4141
Heptane	C_7H_{16}	48.2	4817
Octane	C_8H_{18}	47.8	5450

The quantity of thermal energy given off when a certain amount of a substance burns is called the **heat of combustion.** See Table 3.6. The heat of combustion can be expressed as the thermal energy released when either one gram or one mole of substance burns. If the amount of substance burned is one mole, the quantity of thermal energy involved is called the **molar heat of combustion.**

B.7 USING HEATS OF COMBUSTION

With abundant oxygen gas and complete combustion, the burning of a hydrocarbon can be described by the equation

Hydrocarbon + Oxygen gas ⟶ Carbon dioxide + Water + Thermal energy

"Thermal energy" is written as a product of the reaction because energy is released when a hydrocarbon burns (Figure 3.32). The combustion of a hydrocarbon is a highly exothermic reaction.

The equation for burning ethane (C_2H_6) is

$$2\ C_2H_6 + 7\ O_2 \longrightarrow 4\ CO_2 + 6\ H_2O + \underline{?}\ \text{kJ thermal energy}$$

To complete this equation, the correct quantity of thermal energy involved must be included. Table 3.6 indicates that ethane's molar heat of combustion is 1560 kJ/mol. That is, burning one mole of ethane releases 1560 kilojoules of energy. According to the chemical equation above, two moles of ethane ($2\ C_2H_6$) are burned. Of course, the total thermal energy must correspond to the amounts of all other reactants and products involved. Thus, the total thermal energy released will be *twice* that quantity released when 1 mole of ethane burns. Therefore, the complete combustion equation for ethane is:

$$2\ C_2H_6 + 7\ O_2 \longrightarrow 4\ CO_2 + 6\ H_2O + 3120\ \text{kJ}$$

Appendix D—Silent Discussion Thread, Sheet 1

How does the flow of energy relate to forms of energy?

Response 1:

Response 2:

Response 3:

Appendix E—Silent Discussion Thread, Sheet 2

How does heat of combustion relate to the flow of energy and/or forms of energy?

Response 1:

Response 2:

Response 3:

Appendix F—Silent Discussion Thread, Sheet 3

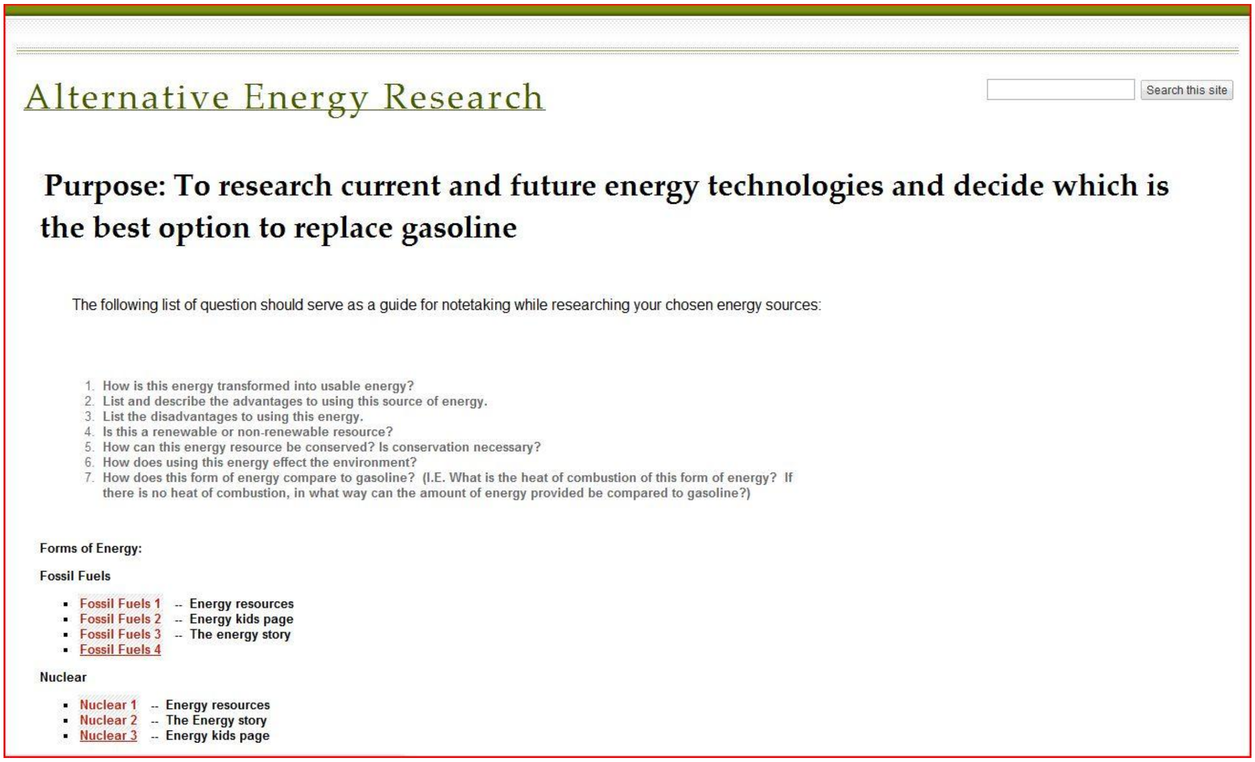
How does the information in this passage relate to the essential question?

Response 1:

Response 2:

Response 3:

Appendix G—Screenshot of Research Website



Alternative Energy Research

Search this site

Purpose: To research current and future energy technologies and decide which is the best option to replace gasoline

The following list of question should serve as a guide for notetaking while researching your chosen energy sources:

1. How is this energy transformed into usable energy?
2. List and describe the advantages to using this source of energy.
3. List the disadvantages to using this energy.
4. Is this a renewable or non-renewable resource?
5. How can this energy resource be conserved? Is conservation necessary?
6. How does using this energy effect the environment?
7. How does this form of energy compare to gasoline? (I.E. What is the heat of combustion of this form of energy? If there is no heat of combustion, in what way can the amount of energy provided be compared to gasoline?)

Forms of Energy:

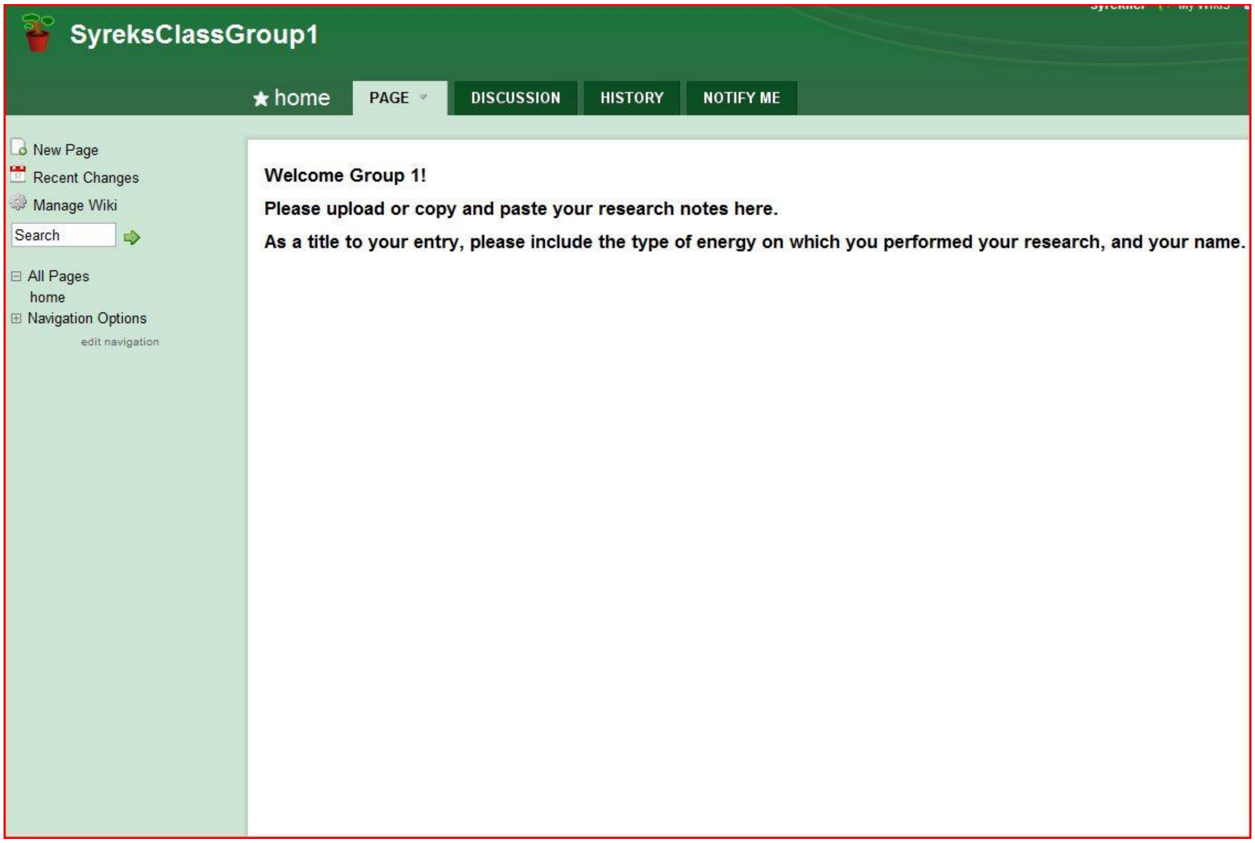
Fossil Fuels

- Fossil Fuels 1 -- Energy resources
- Fossil Fuels 2 -- Energy kids page
- Fossil Fuels 3 -- The energy story
- Fossil Fuels 4

Nuclear

- Nuclear 1 -- Energy resources
- Nuclear 2 -- The Energy story
- Nuclear 3 -- Energy kids page

Appendix H—Screenshot of Research Wiki



Appendix I—Final Project Assignment Sheet

Petroleum and Alternative Energy Final Project

Task:

In the first lesson for this unit, we discussed that petroleum is a finite resource. As is the case with all limited, non-renewable resources, our supply of petroleum will eventually be used up. Your task for this assignment is to use what you have learned about gasoline (a petroleum product) and alternative sources of energy to address the essential question for the unit: If we had to replace gasoline with another source of energy, what would be the best alternative?

To apply your decision in a real-world context, you will persuade government officials to fund research and development for what you feel is the most promising alternative energy source. (Note: if you plan to argue that research and development of alternative energy is not necessary, please talk to me so that we can discuss how you will approach this assignment). To do this, you will either write an open letter in the form of a persuasive essay or create a multimedia presentation to be viewed by policymakers in various levels of government. Your project/letter must include a claim (your point of view), evidence (facts, information, and data that support your claim), and reasoning (an explanation derived from original thought that justifies the evidence and links it to your claim).

Schedule:

- Day 1: Finish any research that still needs to be completed, and begin planning your letter or presentation.
- Day 2: Begin writing your letter or creating your presentation.
- Day 3: Finish writing your letter or creating your presentation.
- Day 4: Peer review and final editing of your letter
- Day 5: Sharing of project on social network

Rubric:

Your letter will be graded using the Base Scientific Explanation Rubric. (Continued on next page)

Component	Level		
	Beginning (Level 1)	**Approaching (Level 2)**	**Meeting (Level 3)**
Claim— a conclusion that answers the original question.	Claim lacks 2 or more items/characteristics from level 3. 0-1 point	Claim lacks 1 item/characteristic from level 3. 2-3 points	Claim is clear, concise, meaningful (nontrivial); makes sense. 4 points
Evidence— Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	Does not provide evidence, or only provides inappropriate evidence (evidence that does not support the claim), no numerical data with appropriate labels. 0-3 points	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence or missing numerical data or appropriate labels. 4-7 points	Provides appropriate and sufficient evidence to support claim. All numerical evidence contains appropriate labels. 8 points
Reasoning— A justification that links the claim and evidence. It shows why the data counts as evidence by using appropriate and sufficient scientific principles.	Either fails to explain or only somewhat explains how & why data/evidence supports claim; chemical explanation is lacking. Several questions needed for clarification. 0-3 points	Moderately explains how & why data/evidence support(s) claim, gives moderate chemical explanation. One or two questions needed for clarification 4-7 points	Clearly, succinctly & logically explains how & why the data/evidence support(s) the claim; accurate chemical vocabulary/explanations are present; no questions for clarification required. 8 points

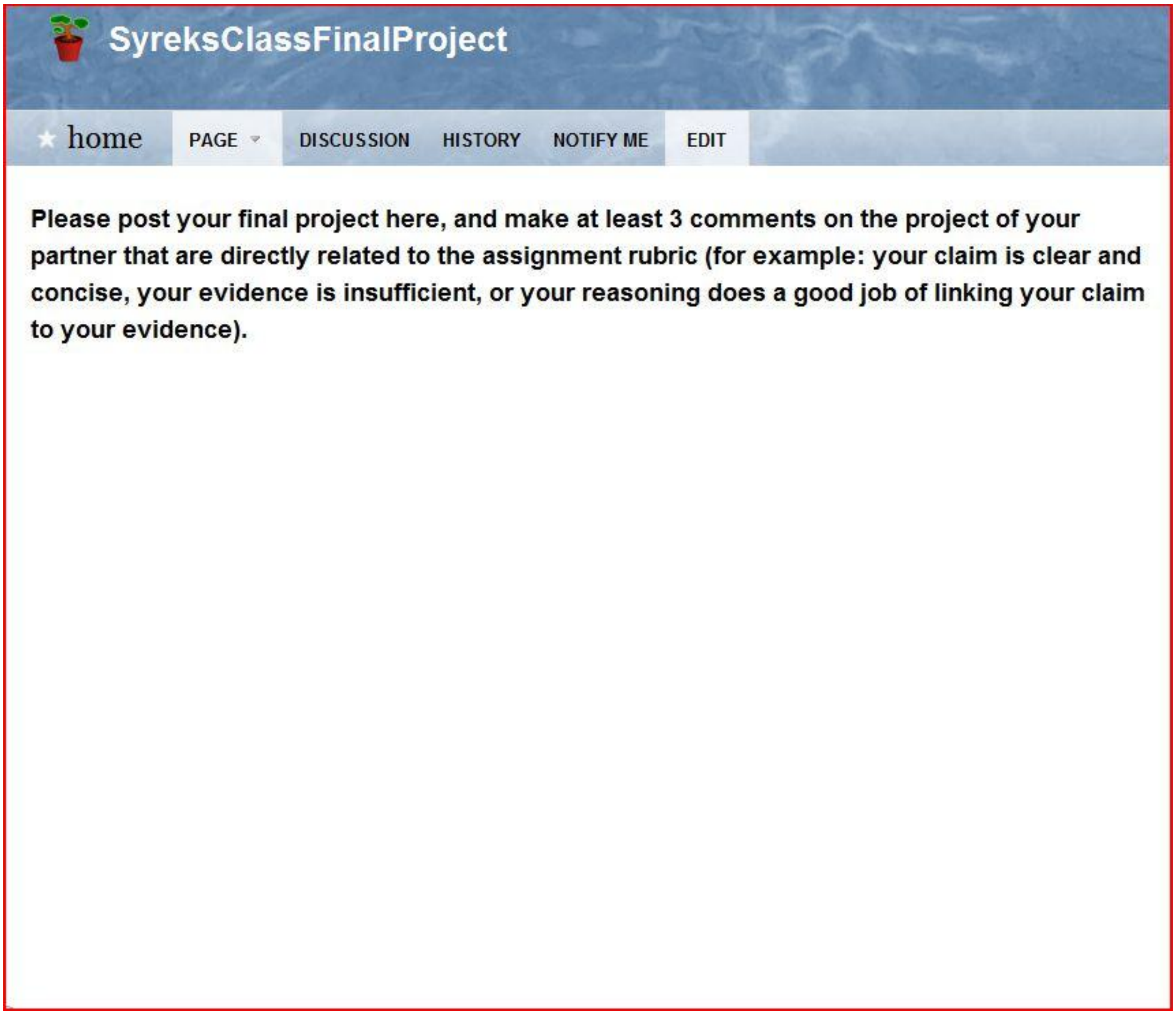
Score = _______________ / 20 possible points

Appendix J—Persuasive Letter/Presentation Planning Guide

Persuasive Letter/Presentation Outline

Greeting and salutation (Since this in an open letter/presentation, it may be addressed to representatives, legislators, or policymakers)	
Paragraph/Slide/Topic 1 Hook the reader and introduce the topic. In the last sentence, write a thesis (your claim), stating the problem and actions needed (like a "should" statement).	
Paragraph/Slide/Topic 2 Provide 2-3 pieces of evidence (facts, information, and data that support your claim) followed by reasoning (an explanation derived from original thought that justifies the evidence and links it to your claim)	
Paragraph/Slide/Topic 3 Provide 2-3 pieces of evidence followed by reasoning	
Paragraph/Slide/Topic 4 Anticipate an opposing viewpoint and provide a counterargument (rebuttal) – provide evidence and reasoning	Some people may think that …. However….
Paragraph/Slide/Topic 6 Conclusion—restate your thesis and summarize key points	
Closing (Sincerely, Respectfully, etc.)	

Appendix K—Discussion Forum for Final Project



Appendix L—Final Reflection Sheet

Name:____________________________

Final Reflection of Petroleum and Alternative Energy Unit

1. What is the most important thing you learned as a result of this unit?

2. How did your thinking change as a result of the learning you did in this unit?

3. What impact did social networking (or the lack of social networking) have on your learning and thinking in this unit?

4. What impact did social networking (or the lack of social networking) have on the outcome of your final project?

5. What changes would you like to see made to this unit?