**Subject area/course**: Science/Chemistry

**Grade level/band**: 11

**Task source**: Summit Public Schools; Author: Trina Lee

**Biodiesel: Making and Selling**

**TEACHER'S GUIDE**

1. **Task overview**:

In this task, students will work in teams to make biodiesel fuel and analyze its properties to compare it to other fuels available. They will manage a budget to produce and advertise their fuel. Students will apply their understanding of chemical reactions and interactions to possibly modify the basic formula for biodiesel fuel and to be able to explain their process in their final report.

1. **Aligned standards:**
2. **Primary Common Core State Standards**

[CCSS.ELA-Literacy.RST.9-10.7](http://www.corestandards.org/ELA-Literacy/RST/9-10/7/) Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

[CCSS.ELA-Literacy.WHST.9-10.4](http://www.corestandards.org/ELA-Literacy/WHST/9-10/4/) Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

[CCSS.ELA-Literacy.WHST.9-10.5](http://www.corestandards.org/ELA-Literacy/WHST/9-10/5/) Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

CCSS.ELA-Literacy.WHST.9-10.1a Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.

1. **Critical abilities**

Research: Conduct sustained research projects to answer a question (including a self-generated question) or solve a problem, narrow or broaden the inquiry when appropriate, and demonstrate understanding of the subject under investigation. Gather relevant information from multiple authoritative print and digital sources, use advanced searches effectively, and assess the strengths and limitations of each source in terms of the specific task, purpose, and audience.

Analysis of Information: Integrate and synthesize multiple sources of information (e.g., texts, experiments, simulations) presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to address a question, make informed decisions, understand a process, phenomenon, or concept, and solve problems while evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

Experimentation and Evaluation: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. Evaluate hypotheses, data, analysis, and conclusions, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Communication in Many Forms: Use oral and written communication skills to learn, evaluate, and express ideas for a range of tasks, purposes, and audiences. Develop and strengthen writing as needed by planning, revising, editing, and rewriting while considering the audience.

Use of Technology: Present information, findings, and supporting evidence, making strategic use of digital media and visual displays to enhance understanding. Use technology, including the Internet, to research, produce, publish, and update individual or shared products in response to ongoing feedback, including new arguments or information.

Interpersonal Interaction and Collaboration: Develop a range of interpersonal skills, including the ability to work with others, to participate effectively in a range of conversations and collaborations.

Modeling, Design, and Problem Solving: Use quantitative reasoning to solve problems arising in everyday life, society, and the workplace, e.g., to plan a school event or analyze a problem in the community, to solve a design problem or to examine relationships among quantities of interest. Plan solution pathways, monitoring and evaluating progress and changing course if necessary, and find relevant external resources, such as experimental and modeling tools, to solve problems. Interpret and evaluate results in the context of the situation and improve the model or design as needed.

1. **Next Generation Science Standards (NGSS)**

### The following NGSS standards can be addressed by this assessment. The practices of constructing explanations and analyzing data are core to the experience, but the teacher can choose any of the Disciplinary Core Ideas (PS1) to focus on.

### [Constructing Explanations and Designing Solutions](http://www.nap.edu/openbook.php?record_id=13165&page=67)

[Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.](http://www.nap.edu/openbook.php?record_id=13165&page=67)

* [Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)](http://www.nap.edu/openbook.php?record_id=13165&page=67)
* [Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)](http://www.nap.edu/openbook.php?record_id=13165&page=67)
* [Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)](http://www.nap.edu/openbook.php?record_id=13165&page=67)

### [Analyzing and Interpreting Data](http://www.nap.edu/openbook.php?record_id=13165&page=61)

[Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.](http://www.nap.edu/openbook.php?record_id=13165&page=61)

* [Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.](http://www.nap.edu/openbook.php?record_id=13165&page=61)

### [PS1.A: Structure and Properties of Matter](http://www.nap.edu/openbook.php?record_id=13165&page=106)

* [The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.](http://www.nap.edu/openbook.php?record_id=13165&page=106)
* [A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.](http://www.nap.edu/openbook.php?record_id=13165&page=106)

### [PS1.B: Chemical Reactions](http://www.nap.edu/openbook.php?record_id=13165&page=109)

* [Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5)](http://www.nap.edu/openbook.php?record_id=13165&page=109)
* [In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)](http://www.nap.edu/openbook.php?record_id=13165&page=109)
* [The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)](http://www.nap.edu/openbook.php?record_id=13165&page=109)

**4-ESS3-1**

Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

1. **Time/schedule requirements:**

As a standalone task, Biodiesel: Making and Selling would take a minimum of two weeks of class time (1 or more hours per day) to complete. If the task is integrated into a unit of study including other lessons to help students learn about intermolecular forces, chemical reactions, and/or chemical equilibrium, the unit would take a minimum of one month.

1. **Materials/resources:**

* Item A: Biodiesel Introduction [Step 1]
* Item B: Biodiesel Budget Constraints [Step 1]
* Item C: Biodiesel Synthesis [Step 2]
* Item D: Biodiesel Analysis [Step 3]
* Item E: Final Lab Report [Step 4]
* Item F: Final Commercial Instructions [Step 5]
* Websites:
  + <http://www.afdc.energy.gov/>
  + <http://www.socalgas.com/innovation/natural-gas-vehicles/policy/fuel-comparison.shtml>
  + <http://www.fueleconomy.gov/feg/current.shtml>
  + http://www.eoearth.org/view/article/160424/
  + Academic Paper - <http://www.academia.edu/5486120/Environmental_Comparison_of_the_Use_of_BioDiesel_and_Gasoline_for_Transportation_-_The_Case_of_Athens>

1. **Prior knowledge:**

Prior to this task, students should be familiar with chemical reactions and interactions as well as how to formulate an explanation based on evidence. During the sample analysis portion of the inquiry, students need to be familiar with the practice of calorimetry. In order to analyze data independently students would need to know about density, molar mass, and calorimetry calculations.

1. **Connection to curriculum:**

This task fits into the chemistry curriculum when students are studying intermolecular forces, chemical reactions, and chemical equilibrium.

1. **Teacher instructions:**

Ideally this task will be integrated into a unit around chemical reactions and chemical equilibrium. The task helps to provide context for these concepts while formatively assessing student understanding of core chemical concepts. In this implementation strategy, Items A-C will be introduced early in the unit to give students context. Item D will be introduced after groups had a few chances to synthesize biodiesel fuel (and had found some success). After analyzing the sample(s) from their initial batches of biodiesel, students will ideally have an opportunity to reformulate their fuel based on their continuing research. The process finishes with students completing the final tasks. The teacher’s existing curriculum for these concepts would be interspersed with Items A-F and time to work on the task.

If a teacher isn’t comfortable weaving this task into the unit, they could also use the task at the end of the unit.

1. **Student support:**

* Close Reading – Lead students through a close reading strategy with the more difficult texts provided. Provide leveled texts from websites such as <http://www.newsinlevels.com/> for language learners or struggling readers.
* Research – Provide students with a list of additional sources for research on formulation of biodiesel fuel.
* Analysis – Have hints available for the various parts of Item D. If students are struggling to progress make sure they ask their group members for assistance before they ask you. If they continue to struggle provide them with a hint. One way to make this quick is to print out the hints on strips of paper so they are ready when you need them.
* Report – Provide alternate report formats for language learners or students with IEPs as needed. Decide what is the most important part of the report for you to assess and focus on it.

1. **Extensions or variations:**

Patent Office – Have students write patent applications that more closely resemble actual applications. The application would include a claim that defines the invention and the constituent parts, an explanation of the process to create the fuel, as well as diagrams that help explain the process and show the product.

1. **Scoring:**

Student work can be scored using the Summit Public Schools Biodiesel Rubric.