Beetle Kill to Bioenergy

Overview:	This lesson explores bioenergy as a clean and alternative energy resource for powering communities. Students will use nonfiction narrative that tells the story of Eagle Valley Clean Energy (EVCE) in Colorado as well as the Bioenergy Alliance Network of the Rockies (BANR). These projects are examples used to assess the social, environmental, and economic impacts of bioenergy and biofuels. A magazine article is used to familiarize the students with bioenergy, the players involved in the process, and the impacts on the community. A video about EVCE will then be used to spur discussion from students based on different stakeholder perspectives. A more detailed explanation of the EVCE and BANR projects is found in the background and can also be used to familiarize students with the project.
Keywords:	biofuel, bioenergy, biomass, feedstock, byproduct, energy portfolio, renewable energy, clean energy, economically viable, supply chain, bioproduct, 1st generation biofuel, 2nd generation biofuel.
Age / Grade Range:	High School
Background:	The Bioenergy Alliance Network of the Rockies (BANR) is one of seven Coordinated Agricultural Projects (CAP). These CAP projects are funded by National Institute of Food and Agriculture (NIFA) and United States Department of Agriculture (USDA). The BANR project is a team of scientists, educators, extension specialists from universities, government agencies, and private industry partners from the Rockies to tackle bioenegy and biofuel solutions specific to their region. In the forests of the Rocky Mountains there has been infestations of pine and spruce bark beetles that have led to widespread tree death in Colorado. Since 1996 there have been 42 million acres of forests impacted. These dead trees are a vast biofuel feedstock resource that require no cultivation, do not compete with food crops, and have a favorable carbon balance compared to other forestry feedstocks. However, because these trees are located in remote areas this feedstock presents challenges through transportation costs to utilize this resource. (http://banr.nrel.colostate.edu/about/) The BANR project is focusing on the use of these beetle-kill trees as an energy resource. A company called Cool Planet Energy Systems is using new technology to produce biofuels and biochar from this feedstock. The company uses a mobile processing plant to move from site to site creating liquid biofuel and a by-product called biochar, which can be used as a soil amendment. The beetle-kill feedstock is also being used to create bioenergy for small communities in Colorado; this bioenergy project will be the focus of this lesson.

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	Eagle Valley Clean Energy is a biomass plant that is using beetle-kill trees to create energy for the Eagle Valley in Colorado. The project has some of the same partners and is using the same feedstock as the BANR project. Eagle Valley Clean Energy combusting this feedstock at a facility in Gypsum, Colorado. This process generates steam to create energy that is powering 12,000 homes in the Holy Cross territory in the Inter-mountain West. Although this lesson focuses on the Eagle Valley Clean Energy plant, teachers may wish to expand the discussion to discuss the BANR project and Cool Planet Energy systems. These same materials can be used to compare and contrast the Cool Planet biofuel production with Eagle Valley Bioenergy Plant to further students understanding of biofuel/ bioenergy feedstocks and processes.
Next Generation Science Standards & Common Core:	**Common core**: **CCSS.ELA-LITERACY.RST.9-10.2** - Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. **CCSS.ELA-LITERACY.RST.9-10.6** - Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address. **CCSS.ELA-LITERACY.RST.9-10.8** - Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. **CCSS.ELA-LITERACY.RST.9-10.9** - Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts. **Next Generation:** **HS-ESS3-1.** - Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. **HS-ESS3-2.** - Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

	HS-ESS3-4. - Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
Goals:	• Students will understand that biofuels are a renewable energy source • Students will understand that 2nd generation biofuels feedstocks are different from 1st generation feedstocks. • Students will understand that biofuels can help local economies by providing jobs as well as energy independence.
Objectives:	• Students and teachers will become familiar with the BANR project. Refer to the background section from this lesson plan. • Students will read "Beetle-Kill Fuels Bioenergy" from *Western Confluence* to learn about a specific bioenergy project, the feedstocks used, and the partners and communities involved. • Students will watch "Bioenergy Day" from *RIVE* to further their understanding of the BANR project. This will be used to spark discussion on the different stakeholder perspectives.
Materials:	• "Beetle-Kill Fuels Bioenergy" from *Western Confluence* - http://www.westernconfluence.org/beetle-kill-fuels-bioenergy/ • Beetle-Kill Fuels Bioenergy worksheet • "Bioenergy Day" from *RIVE* - https://vimeo.com/107651669
Set up:	Familiarize yourself with the following materials: • Background section • Article "Beetle-Kill Fuels Bioenergy" • Video "Bioenergy Day"
Lesson Time:	1 hr.
Introduction (Engage):	As renewable energy technology becomes more widespread it is important to tell the story of success and failures within the field. These stories about countries, cities, and communities converting to alternative energy can raise awareness about new technology and increase interest in science. In this lesson we will look at two stories that tell about bioenergy initiatives that are being implemented to push the boundaries of how biomass can be used in a local area's

	energy portfolio. The narrative style of communication used in this lesson aims to increase engagement and comprehension of science content. Students should become engaged in the stories being presented while taking note of science content being presented. Teachers may want to present background information on EVCE and BANR projects to students through short lecture or by asking student what they know about biofuels, bioenergy, feedstocks, and beetle-kill.
Activity (Explore):	• Students will read article "Beetle-Kill to Bio energy" while completing Beetle-Kill Fuels Bioenergy worksheet. This may be completed individually, in small groups, or as a homework assignment before class.
Explain	• After completing worksheet, students should share their answers with the class while the teacher moderated discussion. All students should have a similar understanding of vocabulary, cost/benefits, and stakeholders before watching the EVCE video.
Elaboration:	• Students will watch the video "Bioenergy Day" to further understand stakeholder involved in EVCE project.
Evaluation:	Students will be divided into groups based on the stakeholders they identified during the lesson. The EVCE project is being used as an example of a progressive local energy project that uses alternative fuel to create clean energy. The U.S. Department of Energy is forming a committee to assess the social, environmental, and economic impacts of this project. The input from the committee will be used to guide decisions for other communities in the Inter-mountain West that have beetle-kill as a local resource. Students should be asked to give informed comments based on their stakeholder perspective to promote or discourage further development of bioenergy plants in the region. It there are time constraints students may be asked to write a statement to be presented to the moderator(teacher). **Possible Stakeholders:** Residents of Vail and Eagle Valleys West Range Reclamation White River National Forest (Forest Service) Evergreen Clean Energy

	Stop Gypsum Biomass Colorado Chapter of American Lung Association Recreationists Coal-fired power plant employees **Possible questions to guide discussion:** Is your stakeholder for or against further development of bioenergy plants? Can your stakeholder provide examples of social, environmental, or economic impacts to support their position. Are there other energy resources that your stakeholder believes are more appropriate for this region?

Additional resources: Where can the teacher go to learn more? List websites or books that might be useful.

banr.nrel.colostate.edu

energy.gov

nextgenscience.org

corestandards.org

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