



# Lesson Plan Design: Life Cycle Assessment of NARA Jet Biofuel

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Northwest Advanced Renewables Alliance Summer Undergraduate Research

## Introduction

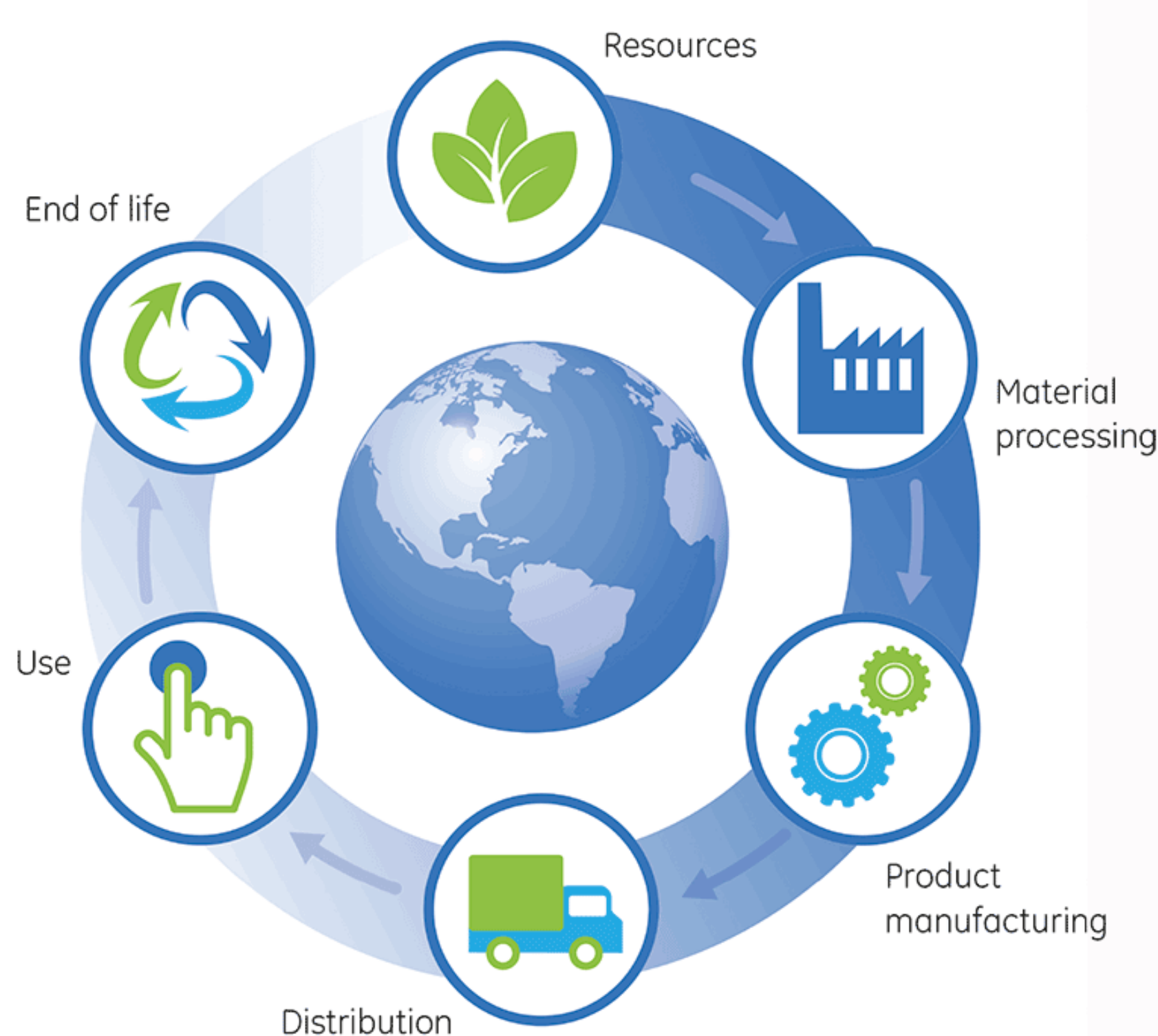
Life cycle assessments are an effective means for analyzing the inputs, outputs, and waste associated with a product's creation, usage, and disposal. The Northwest Advanced Renewables Alliance (NARA) has been utilizing this assessment tool to determine the environmental health impacts of producing jet biofuel from woody biomass when compared to conventional methods of procuring petroleum.

## Objective

This stand-alone lesson seeks to educate students in grades 6 through 8 about the pros and cons of biofuel and the process associated with its creation by developing a life cycle assessment (LCA). Students will also gain a better understanding of their roles in reducing energy consumption in the current energy economy.

## Defining Life Cycle Assessment

The environmental health effects of producing biofuel can be assessed using a life cycle assessment. This tool compiles the inputs, outputs, and overall impact of a product as it moves through its life cycle. The nine impact categories generally assessed are: global warming, ozone depletion, eutrophication, acidification, smog formation, eco-toxicity, human health criteria, human health cancer, and human health non-cancer. In the context of biofuels, the LCA emphasizes the implications for global warming.<sup>1</sup>



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## Lesson Development

This lesson was developed and executed at McCall Outdoor Science School, a place-based science and inquiry lead educational facility. Student feedback from the school's open enrollment week-long middle school environmental science summer camp, McCallogy, was utilized to adjust and refine the lesson.

This work, as part of the Northwest Advanced Renewables Alliance (NARA), was funded by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.

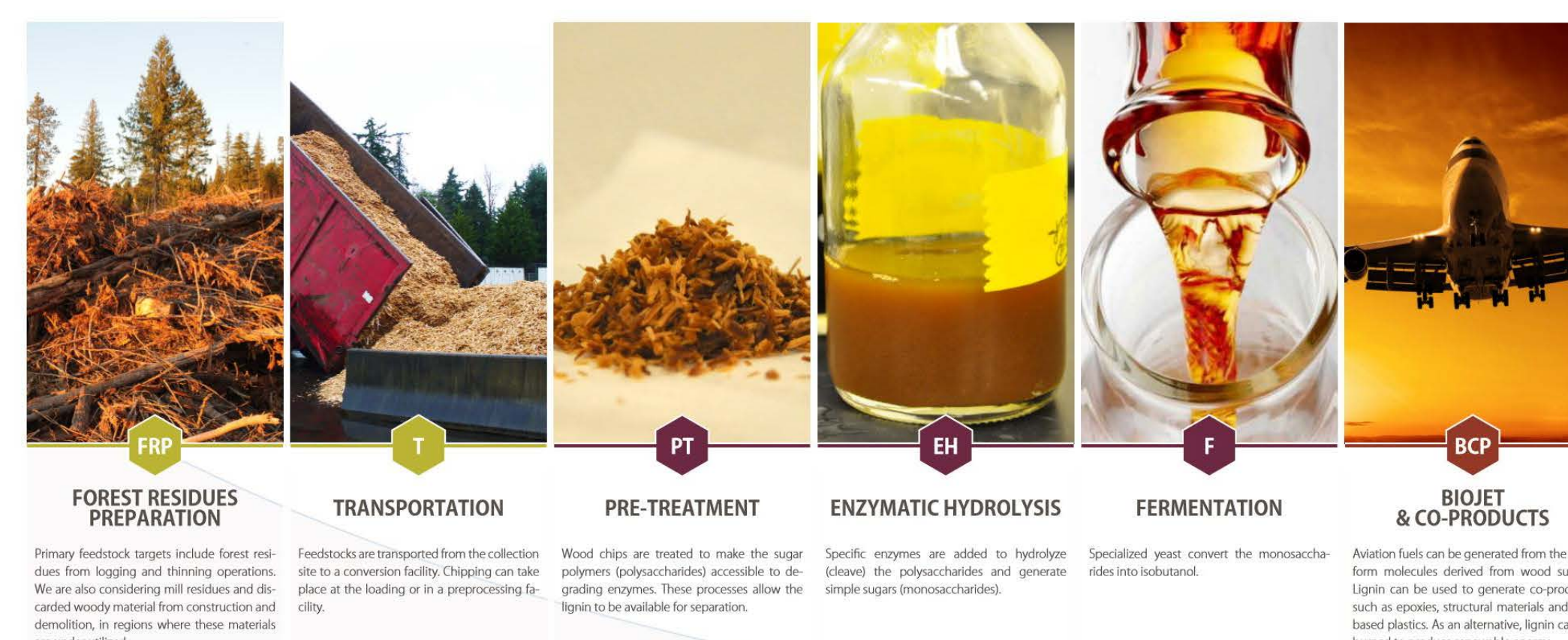
## Method

### Engagement

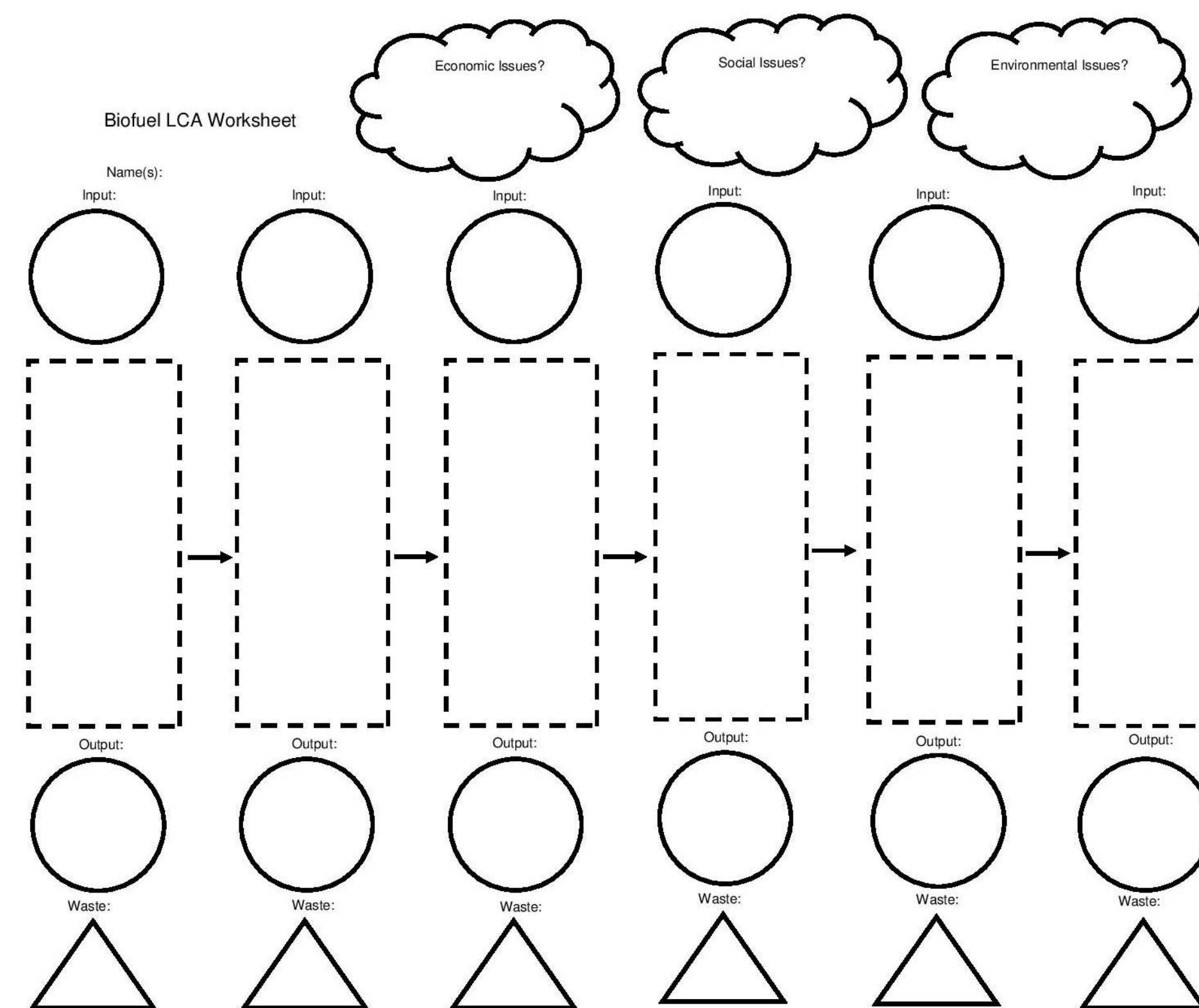
Students begin the lesson by debating the superiority of either paper or plastic grocery bags. This debate leads students to assess the grocery bags beyond simply the bag's usage. As such, students introduce themselves to the concept of a life cycle assessment by considering the origin and disposal of both grocery bag types. Students will also be prompted to discuss other products they may like to compare using an LCA.

### Exploration

Teacher will introduce the concept of biofuels and task students with correctly ordering the steps of the biofuel process as seen below:



Teacher will explain the NARA biofuel process to provide clarity for students. Students will then use deductive reasoning and information provided in the infographic above to complete the LCA worksheet, where students consider the inputs, outputs, and waste of each step in the process of creating biofuel, along with the environmental, social, and economic limitations of biofuel as a fuel source.



### Explanation

Students will discuss their findings and compare their responses with those of their peers. Teacher will provide information about the LCA of conventional jet fuel and allow students to compare and contrast the two fuel sources. Teacher will also lead students to consider any outcomes they may have overlooked in both the worksheet and comparison.

### References

- <sup>1</sup> Pierobon et al, 2014. "Comparative Life Cycle Assessment of NARA BioJet Fuel"
- <sup>2</sup> GE Healthcare Life Sciences

### Elaboration

Students will use an online tool to determine their own carbon footprint. This will provide context for the importance of an LCA in terms of the nine categories for assessing impact. Students will find that their lifestyle would require at least double the resources the Earth is capable of providing if all humans followed their lifestyle.



### Evaluation

Students will journal about which fuel source they find superior: conventional jet fuel or NARA jet biofuel. Teacher will remind students that they may be required to pay more money or suffer some inconvenience to use a biofuel source in the future. This will hopefully provide students with a sense of accountability and moral standing about their role in sustainably meeting the world's energy demands.



Students debate amongst each other about their fuel source preference.

## Discussion

Based on the experiences of students who engaged in the lesson throughout the development stage, this lesson is effective in developing students interests about biofuel and also sparking interest in the waste and consumption associated with their own lifestyles.

## Next Steps

In order to make this lesson accessible to younger or less scientifically inclined students, the worksheet could be modified as a cut and paste puzzle of pre-provided inputs and outputs. This portion of the lesson can most effectively be developed upon the completion of the NARA project, when the final LCA information becomes available.

## Acknowledgements

Special thanks to Mike Frohely, Leslie Dorsey, Aaron Boyles, Mark Wolfden, Ashley Floney, Abby Flowers, Shalonda Robinson, Jessica Curry, and McCall Outdoor Science School.