Environmental Updates

April 2019

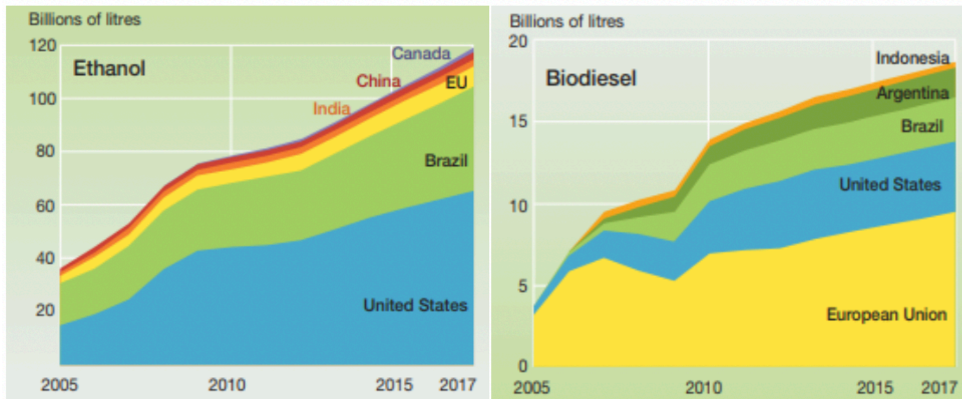
Designed for use with the Global Development And Environment Institute's *Environmental and Natural Resource Economics* textbook

Global Biofuel Production

Prior to the Industrial Revolution in the late 1700s, humans primarily relied on burning biomass, such as wood and dried animal dung, for energy to heat and cook. Modern economies now rely on fossil fuels (coal, oil and natural gas) for over 80% of their energy. Growing recognition of the environmental damaged caused by fossil fuels has led to increased interest in alternative, renewable energy sources including biofuels.

The term biofuel refers to fuels that are derived from biomass (plant or animal matter) that can be regenerated in a relatively short time frame. While fossil fuels come from prehistoric biomass that has been compressed under ground for millions of years, biofuels come from plants or other organisms that have been recently harvested and processed. Because they come from materials that can be rapidly replenished, biofuels are a renewable energy source. Biofuels from plants are sometimes considered to be carbon neutral since although though do they emit

Figure 1: Biofuel Production Trends



Source: Biofuels Vitals Graphic, 2012
https://www.grida.no/resources/6231

carbon dioxide when they are burned (like fossil fuels), this is carbon dioxide that was more recently absorbed from the atmosphere.

Today the primary producers of biofuels are the United States, which makes mostly corn ethanol, and Brazil, which makes ethanol from sugar cane. Biodiesel made from soy or oil seeds makes up a much smaller portion of global biofuel use. Though in theory they could be a cleaner alternative to fossil fuels, biofuels present several environmental challenges.

Not all Feedstocks are Equal

Biofuels can be made from a wide variety of sources, also known as feedstocks. They are classified by feedstock and processing method into four generations:

- 1st Generation biofuels are those made from crops that could be used for food, including corn, sugarcane, and soy;
- 2nd Generation biofuels include fuels made from non-food crops like switchgrass, waste crop residues and forest products, or crops grown on lands that cannot be used for food;
- 3rd generation biofuels are made from algae that is farmed for oil extraction;
- Finally, 4th generation involving photobiological solar fuels and electrofuels (which store electrical energy from renewable sources) is in the early stages of development.

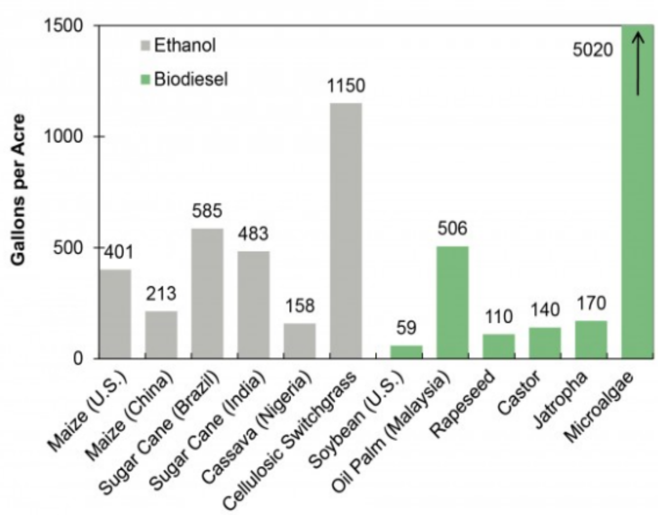
The amount of land and inputs needed to produce biofuels varies greatly based on the feedstock used. For example, as shown in Figure 2, one acre of land in the U.S. can be used to produce 401 gallons of ethanol from corn, or 5020 gallons of biodiesel from microalgae. Though biodiesel from algae sounds like a promising source, it is still in the early stages of development, and commercial production has not taken off as was projected when the technology first emerged. This is due in part to the fact that land is not the only input needed for biofuel production, and algae turn out to be extremely water and energy intensive to produce.

Inputs to Production are Not Carbon Neutral

Although the carbon dioxide emitted by burning corn ethanol may be equivalent to the carbon dioxide the plants removed from the atmosphere, this does not take account of the carbon dioxide emitted when running machinery to plant and harvest the crops, producing fertilizers and pesticides used in production, and processing the raw materials. Some case studies have found that there is a net energy loss in biodiesel production when you consider all of the inputs needed. For example, one study found that producing biodiesel from soy required 27% more energy than is produced, while switchgrass required 57% more energy than is produced (Pimentel & Patzek, 2005).

Further, many of these crops are treated with chemical pesticides that can contribute to water contamination and wildlife destruction. These crops can also be water intensive if they are grown in areas where they need to be irrigated, or if like algae they must be grown in water. This is one reason why biofuels made from waste materials are a popular option. Biodiesel from waste cooking oils, and ethanol made from the stalks and leaves of plants used for food are a more environmentally friendly biofuel alternative, but still make up only a small portion of the biofuel used across the globe.

Figure 2: Biofuel Yields by Feedstock



Source: University of Michigan Center for Sustainable Systems

Land Use Change Matters

Another concern with the sustainability of biofuels relates to the land they are grown on. In many regions there has been direct land use change as forests are cleared to make way for crops that are used for biofuel production. In other areas there has been indirect land use change as land previously used for food production has been converted to biofuel feedstock production land, causing forests to be cleared to create new agricultural plots.

Palm oil production in Indonesia is one example where rapid land use change for oil crop production has occurred. Indonesia is now the world's leading producer of palm oil, which is used in food, cosmetics and for biodiesel. Palm plantations cover close to 12 million acres of land in Indonesia, much of which was previously tropical forest. With the loss of tropical forest, a number of species, including orangutans and pygmy elephants are now critically endangered while residents have to deal with local environmental destruction. The increase in palm oil production in Indonesia has been driven in part by increased consumption of biodiesel in Europe, due to a 2008 European Union mandate that 10% of transport fuels come from sustainable sources by 2020, and also in the United States due to a 2007 energy bill aimed at reducing vehicle emissions by increasing biofuel use. Since biofuels were considered to be carbon neutral, adding corn ethanol to gas and vegetable oils to diesel became an easy way to meet new emissions targets.

In many cases biofuel production is also not economically feasible without subsidies. The two primary world producers of biofuels: the United States and Brazil, are only able to produce these fuels with the support of subsidies from their respective governments. With recent improvements in solar photovoltaic and wind energy technologies, combined with increases in natural gas production and growing recognition of the environmental issues associated with biofuel production, the industry is not as promising as it once seemed.

Many countries are now recognizing these limitations and beginning to promote more sustainable biofuel policies. For example, in 2017 the U.K. Royal Academy of Engineering produced a report titled "The Sustainability of Liquid Biofuels" outlining a path forward for biofuel use. The report stated that if the region wants to achieve the proposed 80% reduction in carbon by 2050 they will need to use biofuels, but they should focus on second generation fuels, specifically those made from wood waste and agricultural residues. Additionally, the report promoted a focus on conducting complete life cycle assessments and considering all aspects of sustainability when selecting feedstocks.

Today there is a growing recognition that not all biofuels are equal, and that the negative environmental impacts of some biofuels can be much greater than it once seemed. It is likely that biofuels still have a role play in carbon reduction strategies, but their use needs to be more carefully planned and may be more limited than once hoped.

This update specifically relates to *Environmental and Natural Resource Economics: A Contemporary Approach* Chapters 11 and 16. For more information about the books, teaching materials, and research, see www.gdae.org

Sources:

Aro, E. M. (2016). From first generation biofuels to advanced solar biofuels. *Ambio*, *45*(1), 24-31.

Center for Sustainable Systems, University of Michigan. 2018. "Biofuels Factsheet." Pub. No. CSS08-09. Available at: http://css.umich.edu/factsheets/biofuels-factsheet

Pimentel, D., & Patzek, T. W. (2005). Ethanol production using corn, switchgrass, and wood; biodiesel production using soybean and sun flower. *Natural resources research*, *14*(1), 65-76.

Riccardo Pravettoni, UNEP/GRID-Arendal (2012). World biofuels production trends. Available at: https://www.grida.no/resources/6187

Lustgarten, A. (2018) Palm Oil Was Supposed to Help Save the Planet. Instead It Unleashed a Catastrophe. New York Times, November 20th, 2018. Available www.nytimes.com/2018/11/20/magazine/palm-oil-borneo-climate-catastrophe.html?nl=top-stories&nlid=48442206ries&ref=cta

World Wildlife Federation (2019). Borneo Deforestation. Available wwf.panda.org/our_work/forests/deforestation_fronts/deforestation_in_borneo_and_sumatra/

Royal Academy of Engineering (2017). Sustainability of Liquid Biofuels. London. Available at www.raeng.org.uk/publications/reports/biofuels