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How big is the bioenergy piece of the energy pie? Who cares—it's pie!

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How Big is The Bioenergy Piece of the Energy Pie? Who Cares—It's Pie!

Cut my pie into four pieces, I don't think I could eat eight.
—Yogi Berra

Estimating the practical limits to how much bioenergy could be produced in the future has been an academic sport in recent years, but is not a useful activity. Because biological photosynthesis usually results in less than 1% of available light energy being stored in biomass, there are easily calculated limits to the contribution that biological systems can make to human needs for energy. Recognition of this limitation provokes some authors to dismissive attitudes about bioenergy in favor of alternative technologies such as solar (Michel, 2012). However, biobased energy contributes approximately 10% of all human energy use at present (IEA, 2012), about 4.3 times as much as all hydro, and 11.4 times as much as all other renewables (e.g., solar, wind, and geothermal) combined. Thus, bioenergy is an important component of our overall energy system, and could be much larger without invoking dramatic changes in land use. For example, about 56% of the 1.2 billion tons of municipal solid waste in California is lignocellulose, which could be captured and converted to energy (Youngs and Somerville, 2013).

Slade and colleagues (2014) recently reviewed the results of more than 120 estimates of the future contribution of bioenergy to the global energy use of about 550 EJ/year. The estimates vary widely, depending on the assumptions made, most of which reportedly had an optimistic bias. The estimates ranged from 22 to 1,272 EJ for energy crops, 10 to 66 EJ for agricultural residues, 12 to 120 EJ for wastes, and 60 to 230 EJ for forestry. Slade et al., concluded that nothing useful could be accomplished by further modeling studies or speculation about the magnitude of future bioenergy production and that the path forward is to learn by doing. Even at the pessimistic end of the estimates, bioenergy could contribute at least another 20% of total energy use.

One of the drivers for the recent discourse about the potential contributions of different sources of energy appears to be the widespread recognition in the scientific community that carbon loading of the atmosphere may have undesirable environmental consequences. Organizations that have grappled with how we might reduce the use of fossil fuels inevitably come to the recognition that, pending a breakthrough in fusion research, there is no straightforward path to the eventual displacement of fossil fuels (NAS, 2009). As participants in several of the large multidisciplinary analyses of our energy future, we have come to the opinion that relatively few people understand the whole picture. There is a natural tendency for colleagues working in one field or another to think that their favorite technology is important and very promising, and that if there were just more research and development dollars in their field things would be progressing much better. There are also a lot of people who do not welcome change in the energy sector because it is disruptive to their interests. Finally, many people are concerned about the ways in which we use land and water and are concerned about possible negative effects of energy technologies that impact these fundamental resources. Thus, consensus about the future of energy in general, and bioenergy in particular, is elusive for many reasons.

It is clear that we will need a wide variety of solutions to meet our growing energy appetites sustainably. It is also clear that bioenergy has a place at the table. Several recent studies centered on curbing greenhouse gas emissions, using different approaches, have reached the conclusion that deploying all known low carbon technologies, including nuclear energy and carbon capture and storage (CCS), may be needed (Greenblatt et al., 2011; IPCC, 2014; Kainuma et al., 2013; McCollum et al., 2012; Williams et al., 2012). For example, even with other optimistic assumptions, such as electrification of all rail transport and a large percentage of the light duty fleet, heroic efficiency improvements and renewable electricity from wind, solar and geothermal, biofuels are the only available option foreseeable at large scale in the next 40 years for reducing emissions from the heavy duty fleet and aviation (Greenblatt et al., 2011; McCollum et al., 2012). Perhaps most controversially, biomass, when combined with CCS, is one of the few carbon negative options (IPCC, 2014; Keith, 2001). In other words, all the wedges are important (Pacala and Socolow, 2004), regardless of exactly how big they are.

In some ways, it is challenging to consider quantitative estimates of probable future contributions of different energy technologies as a worthwhile scientific activity. All technologies will be physically limited to some extent. While this can be estimated, social and economic limitations may be

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far more important to the actual trajectory of adoption. Take nuclear energy as a case in point. The value in technical estimates is largely or entirely political because such numbers are often used to justify or negate technologies that organizations or individuals want to promote or impede. The popular press routinely confuses the predictions of computer models with scientific discoveries, lending credence to the political uses of hypothetical scenarios (Youngs and Somerville, 2014).

Estimates of how large the contribution of bioenergy could be are inherently uncertain. What is certain is that large amounts of unused biomass are available today that can contribute substantially toward creating employment, reinvigorating rural economies, and achieving energy and climate security. Using that biomass efficiently, sustainably, and for the highest impact value entails solving a lot of interesting scientific and engineering challenges. The 50-year slog toward the recent historic achievement in commercial-scale lignocellulosic biofuel production is an example of how hard some problems in the field are. Since plant biomass is likely to be the main source of renewable fixed carbon far into the future, anything we can discover about how to utilize biomass is important, valuable, and a far better use of time and effort than guessing how big exactly the wedge might be.

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