Limits of Bioenergy for Carbon Mitigation

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Just how much bioenergy can the world produce? Giorgio Ruffolo Fellow Alexandre Strapasson discussed his work on this question in the HKS Energy Policy Seminar and reviewed models he helped to develop which project the potential for bioenergy under different scenarios.

Currently (as of 2015), Strapasson explained, biomass fuels around 11% of world primary energy consumption. The U.S., Strapasson noted, is the dominant player in biofuels, producing 62 billion liters of biofuels, followed by Brazil with 32 billion liters and the EU with 16 billion liters in 2015.
Although such energy, Strapasson said, is "almost never" fully carbon neutral, since energy is expended in its production, compared to fossil fuels, the same amount of biomass energy can be considered to produce significantly less carbon, since carbon released in burning biomass will largely be re-absorbed by the next crop.

In essence, bioenergy may be considered a form of solar energy, Strapasson suggested—plants capture energy from the sun that can then be used as fuel—with an advantage over solar photovoltaics in that bioenergy is usually more readily stored and dispatchable than photovoltaic solar energy. Bioenergy could therefore be part of a strategy to reduce carbon emissions from the energy sector—but any projections of the role bioenergy might play in meeting future energy needs must understand the inherent constraints limiting potential bioenergy production—constraints imposed by land availability, the limited efficiency of photosynthesis (a maximum capture of about 2% of solar energy to date), and the finite amount of water and nutrients that may be available for plant growth.

Furthermore, land and other resources available for bioenergy production must be considered in the context of other potential land uses—especially food production, which may use more or less land, depending on variables like the average calories consumed, the amount of meat eaten, or the efficiency of agricultural land use. The willingness of policymakers to adopt policies to promote bioenergy production, Strapasson noted, is likely to depend on there being no significant conflict perceived among bioenergy production, forest conservation and food production.

With these variables and more in mind, Strapasson said, he and his colleagues collaborated to develop a "global calculator," an "open access global model for energy, food and land use, aiming to inform the climate debate." The calculator shows a range of possible values for total sustainable bioenergy production in 2050, from a low of 70 Exajoules (EJ)/year (compared to 60 EJ/y in 2015) to a high of 360 EJ/y under an extreme scenario in which all factors were aligned optimally for biofuel production.

An alternative methodology, Strapasson suggested, could approach the question of bioenergy potential in a limited geographic areas as the product of a finite resource, land, which we may anticipate will follow some form of bell curve in terms of land use change—with rapid growth eventually declining to zero over time, setting a limit on the expansion of energy crops in constrained areas.

Strapasson spoke as part of the Kennedy School's Energy Policy Seminar Series, which is sponsored by the Consortium for Energy Policy Research of the Mossavar-Rahmani Center on Business and Government. The session was chaired by Henry Lee, Director of the Belfer Center's Environment and Natural Resources Program.