Letter to the Editor

Understanding the Climate Mitigation Benefits of Product Systems: Comment on "Using Attributional Life Cycle Assessment to Estimate Climate-Change Mitigation . . . "

Anthropogenic climate change can only be limited to safe levels, an aspiration expressed in the United Nations Framework Convention on Climate Change, if humans stop releasing carbon dioxide from the combustion of fossil fuels (FFs) long before economically available fossil resources are exhausted. Climate-change mitigation can hence only be achieved through implementation of policies that prevent the extraction and combustion of FFs or that achieve a universal implementation of emissions controls through effective CO_2 capture and storage, or through geoengineering. Different policy approaches either make the unmitigated utilization of FFs so expensive that it becomes unattractive—carbon taxes and tradable permits—or outlaw it outright through command-and-control approaches. Such policy instruments can be complemented by measures such as urban planning, energy efficiency, and technology development and deployment.

In a recent Forum article, Plevin and colleagues (2014) assert that consequential life cycle assessment (CLCA) can inform policy makers about climate-change mitigation benefits, generally, and, in particular, of biofuels. At the same time, they claim that attributional life cycle assessment (ALCA) can easily mislead policy makers and may generally do so. Plevin and colleagues mix the concepts and terms associated with attributed emissions and those associated with consequences, which leads to flawed conclusions.

ALCA is a method to trace the pollution and resource use associated with a product system (i.e., the production, delivery, operation, and disposal of a product). The key idea is to identify the share of total pollution caused by a specific product (Heijungs 1997). CLCA aims to model the consequences of a decision, but its scope is less clearly defined (Zamagni et al. 2012). It commonly focuses on the production (upstream) consequences by taking into account marginal production technologies and, sometimes, changes in the prices of resources as a result of changes in demand. The downstream consequences of introducing a product on the user through changes in production recipes (for intermediate products) and consumption behavior (for final products) are rarely addressed, but would be required for a fully consequential analysis, as suggested by Plevin and colleagues.[1]

Plevin and colleagues claim that CLCA, through taking into account indirect land-use change and the degree to which a biofuel substitutes for gasoline, can be used to ascertain the contribution to climate-change mitigation arising from the introduction of biofuels. I cannot see why such an analysis would be necessary. Introducing biofuels, by itself, does not produce climate-mitigation benefits, because it does not prevent the unmitigated combustion of FFs. As long as there is no policy in place to restrict the combustion of FFs, introducing alternative fuels may, at best, delay the combustion of the remaining, economically extractable FFs. It is now a well-established insight of climate science that shifting the timing of emissions on a decadal time scale does little to affect the degree of climate change to be expected (Meinshausen et al. 2009).

Biofuels or any other technological alternative to FF use, whether it is energy efficiency, nuclear, or renewable energy, will only *cause* climate-change mitigation if they, by themselves or in combination, permanently undercut the cost of utilizing FFs, so that FFs will be left in the ground.[2] Most analysts agree that this will not occur merely as a result of technological progress, but that such an outcome can only be achieved if the climate and other external costs of FF combustion are internalized through policy. Emissions reductions are hence necessarily the *consequence* of a *policy addressing FF emissions*. Well, if product systems, such as biofuels, do not *cause* climate mitigation, I would argue there is less need for an analysis that builds on the concept of causality. The point, here, is that causality is not the property of the product system (biofuel), but of policies. Whereas the evaluation of a single product-oriented policy instrument, such as a fuel mandate or subsidy, would well fit into the objective of CLCA as defined above, climate policy is commonly seen as requiring a set of instruments. It is hence questionable whether the analysis of a single instrument in isolation is meaningful. What is the role of product systems, such as biofuel or electric vehicles, in climate policy? People will not want to give up using energy for transportation, communication, or food production and preparation. Low- or zero-emissions alternatives are important because they enable people to still do the things they like to do while not causing climate change or, at least, slowing down their contribution to climate change. Policy makers hence have a need to understand what services we can still enjoy when policies to restrict FF emissions are in place. For competitive reasons, they might also like to promote the introduction and development of technologies that will thrive under such policies. Hence, understanding the amount of emissions required by different product systems for delivering specific services may well be of interest to policy makers. This is exactly what ALCA can deliver, even if I would argue that such a life cycle assessment (LCA) should take into account other changes expected in the economy, such as increased efficiency or a cleaner electricity mix.

I would like to remind the reader that LCA is a method developed to assess the emissions and resource requirements

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associated with product systems. A product system comprises the activities required to deliver, utilize, and dispose of a product. The fuel that is extracted and combusted to produce and propel my car is part of the product system "car"; the fuel that is not extracted to propel my bicycle is *not* part of the product system "bicycle." I can use ALCA to analyze the greenhouse gas (GHG) emissions associated with commuting to work by car or bike. Based on such an assessment, I would assert that, by biking to work, I am responsible for fewer GHG emissions than my colleague who drives.

Consequential analysis needs to go beyond product systems. If I want to assert the complete effect on global GHG emissions of my biking, rather than driving, to work, then effects on the flow of rush traffic, the investment decisions of the road authority, the example I provide to others, and the marginal effect on oil and car prices, all need to be taken into account. Plevin and colleagues appropriately construct an example where all activity in an economy is addressed. In my opinion, such climate mitigation analysis necessarily needs to cover the global economy over a longer time horizon. The analytical tools for such a global analysis are well established in the climate research community; they are called integrated assessment models and have been extensively used to evaluate the effect of the availability of technologies on the cost and degree of climate mitigation under different policies (Nakicenovic and Swart 2000). Not even these large models, however, encompass all causal mechanisms suggested above. LCA can potentially further strengthen the representation of technologies in these models, but it would be foolish for the LCA community to attempt reinventing the wheel.

For LCA, this discussion raises the questions as to what causal connections should be part of CLCA. Should CLCA still be about product systems? In this case, the question of what happens with the gasoline that I would have used if I had fueled my car with conventional fuel instead of biofuel would be outside the scope of the biofuel CLCA. Or, should CLCAs be about policy? In this case, would we then analyze all types of policies, for example, carbon taxes, or only those directed at products, such as minimum biofuel requirements? In my opinion, LCA should still be about product systems, although life cycle aspects may be considered in other assessment models and LCA results may be interpreted together with the results of other models that analyze, for example, the rebound effect or revenue recycling. Further, any assessment model will have to limit the causal connections and mechanisms that are included, for both scientific and practical reasons. In any case, the scope description of CLCAs should pay more attention to describing and justifying the causal connections and mechanisms taken into account.

There is one point on which I agree with Plevin and colleagues. We should avoid giving the false impression that the introduction of a specific technology causes climate mitigation. Unfortunately, it is not only LCAs that risk misleading policy makers and the public in that manner (Arvesen et al. 2011). Whereas low-emissions technologies are necessarily part of a mitigation pathway, it is not these technologies that cause the mitigation of climate change, and maybe not even the carbon-curtailing policies that lead to the utilization of such technologies, but the political processes and decisions leading to the implementation of carbon-curtailing policies. Of course, voters and decision makers will be more inclined to support such policies if low-emissions technologies are commercially available and attractive. Further, they may need an LCA to determine whether the product system associated with a technology has low emissions, compared to competing technologies.

Notes

1. One should be careful, however, to note that the attributional-consequential dichotomy is constructed for the sake of argument. In practice, many LCAs are prospective based on scenarios for identified variables or explore the effect of identified causal changes while modeling the remainder of the system in an attributional manner (Zamagni et al. 2012).
2. The same argument has been applied to the voluntary curtailment of consumption (Alcott 2008).

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References

Alcott, B. 2008. The sufficiency strategy: Would rich-world frugality lower environmental impact? *Ecological Economics* 64(4): 770–786.

Arvesen, A., R. M. Bright, and E. G. Hertwich. 2011. Considering only first-order effects? How simplifications lead to unrealistic technology optimism in climate change mitigation. *Energy Policy* 39(11): 7448–7454.

Heijungs, R. 1997. Economic drama and the environmental stage. PhD thesis, Center for Environmental Science, Leiden University, Leiden, the Netherlands.

Meinshausen, M., N. Meinshausen, W. Hare, S. C. B. Raper, K. Frieler, R. Knutti, D. J. Frame, and M. R. Allen. 2009. Greenhouse-gas emission targets for limiting global warming to 2°C. *Nature* 458(7242): 1158–1162.

Nakicenovic, N. and R. Swart, eds. 2000. *IPCC special report on emissions scenarios*. Cambridge, UK: Cambridge University Press.

Plevin, R. J., M. A. Delucchi, and F. Creutzig. 2014. Using attributional life cycle assessment to estimate climate-change mitigation benefits misleads policy makers. *Journal of Industrial Ecology* 18(1): 73–83.

Zamagni, A., J. Guinée, R. Heijungs, P. Masoni, and A. Raggi. 2012. Lights and shadows in consequential LCA. *International Journal of Life Cycle Assessment* 17(7): 904–918.