Letter to the Editor

Can the Predictions of Consequential Life Cycle Assessment Be Tested in the Real World? Comment on "Using Attributional Life Cycle Assessment to Estimate Climate-Change Mitigation..."

There is much to agree with in the recent article by Plevin and colleagues (2014) and also much to disagree with quite strongly. For example, the researchers are right to say that life cycle assessment (LCA) practitioners need to be more careful and circumspect in the way we state our conclusions. As they note, it is correct to state that the calculated global warming impact (GWI) of a given fuel is some given fraction of the GWI of gasoline, calculated in a defined way. It is incorrect to say that using 10 billion gallons of that fuel will reduce greenhouse gas (GHG) emissions by a certain amount. The two of us have sometimes erred in this regard and will try to do better in the future.

Unfortunately, Plevin and his coauthors are not as circumspect and modest in their claims for the value of consequential LCA (CLCA) as they would like others to be when using and reporting on the results of attributional LCA (ALCA). Their recent article claims that ALCA misleads policy makers and that CLCA (or a mix of CLCA and ALCA) will provide a better description of the real world. This is a statement of belief and not a statement of demonstrated fact. CLCA studies usually model three or four processes consequentially, using economic models, and then use ALCA tools and databases, such as ecoinvent, to model the 4,000 or so background processes in the overall system. In reality, their CLCA studies are less than 0.1% CLCA and more than 99.9% ALCA. (Can such an approach really claim to be CLCA?)

The crucial difference between CLCA and ALCA is therefore the use of economic models to estimate market outcomes. *Where is the proof that these economic models do, in fact, provide superior predictions or scenarios? How, exactly, have these economic models been tested against reality? How do we know that they actually predict anything correct or useful about the real world?*

This is not mere academic quibbling . . . if the economic models cannot be shown to predict anything useful about the real world, why on earth would we want to use them? (For a powerful critique of the assumptions of traditional economics on which these models are based, we suggest reading chapters 3 and 4 of *The Origin of Wealth* [Beinhocker 2006]).

We remind Plevin and colleagues (2014), and our readers, that the ability to falsify hypotheses is at the very center of science and therefore at the center of policy claiming to be based on science. If CLCA hypotheses (or scenarios) cannot be tested and falsified, then they are *not* based on science. They are dogma, nothing more. We respectfully, but firmly, request that Plevin and his coauthors document the testing done on the economic models they wish us to use in CLCA.

Is there evidence that the economic models available may not be able to provide science-based regulation? Yes. The U.S. Environmental Protection Agency (EPA) chose FASOM and FAPRI, two global economic models, to "differentiate the contribution of the land-use change to one fuel vs. another" in the Renewable Fuel Standard (RFS2) program (EPA 2010, 310). These models differentiate the contribution of one biofuel versus another by assigning responsibility for overall land-use change among the different biofuels supposedly driving this change. The regulations based on the output of these models *assume* that the land-use change is directly proportional to the amount of each biofuel produced. Thus, the land-use change *per gallon* of biofuel is assumed to be the same at 1 gallon, 1 million gallons, or 1 billion gallons of biofuel produced. In mathematical terms, the system modeled is assumed to be linear.

If the system modeled were linear, the land-use change associated with the overall biofuel scenario mandated by the U.S. Energy Independence and Security Act of 2007 (EISA) would be equal to the sum of the land-use changes associated with the individual fuels mandated by the EISA. *But, it is not.* The overall land-use change predicted by the model when all biofuel volumes are changed ("shocked") at once is approximately half of the land-use change calculated when the biofuel volumes are changed one at a time (EPA 2010, 494). Therefore, the EPA is applying a linear approach to a decidedly nonlinear system and fails in its primary objective—differentiating the contribution of one fuel versus another to the overall predicted land-use change. The California Air Resources Board (CARB) chose a similar linear approach to a nonlinear system of economic models (CARB 2009).

It may eventually be possible to use economic models to reliably predict indirect GHG emissions resulting from biofuels. *But, it is impossible to meet the objectives of LCA, and to form unbiased policy based on LCA, when different system boundaries are deliberately applied to the products being compared in the LCA.* This is what is actually being done. Indirect effects, estimated using CLCA, are assessed against biofuels, but no one at the EPA or CARB has yet estimated the indirect GHGs of petroleum fuels. Thus, the LCAs done comparing biofuels and petroleum fuels are inherently biased against biofuels.

What are the indirect GHG effects of petroleum use? Here are three examples:

- As petroleum prices rise, other energy sources will be used, when possible, in place of oil, for example, burning coal instead of oil to produce electricity or making synthetic liquid fuels based on coal, with its much higher GHG

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emissions per megajoule (MJ). The synthetic liquid fuels technology is used in South Africa and planned for China (Ou et al. 2010). Thus, biofuels should be "credited" with their market-mediated reduction in coal use and its attendant high GHG emissions.
- Continued use of fossil fuels (FFs) drives global warming, especially in the Arctic. As the Arctic tundra and shallow polar seas warm, they may release gigatons of methane from methane clathrates, with a huge GWI. Substitution of FFs with biofuels could reduce net GHG emissions and thereby reduce the release of Arctic methane.
- Petroleum exploration in ever more remote areas, such as the Peruvian Amazon, will require road building, which will increase human settlement in lands adjacent to these roads and subsequently more land clearing and agriculture, with its attendant GHG releases.

These and other indirect GHG effects of petroleum exploration, production, and use cry out for research. No such studies have been done, 6 years after Searchinger first used CLCA to estimate indirect GHGs resulting from biofuels (Searchinger et al. 2008). This glaring omission is a black eye for the EPA, CARB, and the regulatory community in general.

Thus, Plevin and colleagues (2014) have it exactly backward. CLCA, not ALCA, is being used to mislead policy makers by applying different system boundaries to unfairly penalize biofuels and aid petroleum fuels.

Economic modeling and CLCA have not been proven to provide superior real-world predictions, compared to conventional ALCA. Until the proponents of CLCA can offer such proof, we are under no obligation to accept their claim that CLCA will necessarily provide better guidance to regulators. Using CLCA in its current state is like taking an experimental and unproven radar system and then using that radar to guide real airplanes around real mountains. The resulting crashes really matter.

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