

Toward Rational Management of GHG Emissions from Biofuels

WORKING PAPER

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ABSTRACT

Public policy supports biofuels for their benefits to agricultural economies, energy security and the environment. The last rationale is premised on greenhouse gas (GHG, "carbon") emissions reduction, which is a matter of contention. The issue is challenging to resolve because of critical but difficult-to-verify assumptions in lifecycle analysis (LCA), limits of available data and disputes about system boundaries. Although LCA has been the presumptive basis of climate policy for fuels, careful consideration indicates that it is inappropriate for defining regulations. This paper proposes a method using annual basis carbon (ABC) accounting to track the stocks and flows of carbon and other relevant GHGs throughout fuel supply chains. Such an approach makes fuel and feedstock production facilities the focus of accounting while treating the CO₂ emissions from fuel end-use at face value regardless of the origin of the fuel carbon (bio- or fossil). Integrated into cap-and-trade policy and including provisions for mitigating indirect land-use change impacts, also evaluated on an annual basis, an ABC approach would provide a sound carbon management framework for the transportation fuels sector.

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INTRODUCTION

Biofuels have entered the transportation energy portfolio for several reasons including reduction of dependence on petroleum imports (Duffield and Collins 2006). This energy security rationale dovetails with other policy goals of bolstering markets for farm commodities, lowering the need for crop support programs and fostering rural economic development (Brown 2008). Biofuels have also been promoted for environmental reasons, including reduction of greenhouse gas (GHG) emissions, but that issue has become controversial. Differences in view regarding net energy and GHG benefits compared to petroleum fuels were reviewed by Farrell et al. (2006), for example, who concluded that corn ethanol had modest net GHG benefits based on a meta-analysis of traditional fuel lifecycle analysis (LCA) studies.

The sufficiency of standard fuel LCA methods, which only count direct, supply-chain impacts, has been questioned, however. Such attributional LCA does not count indirect, economically induced impacts that occur as a consequence of commodity market effects. It therefore misses the emissions due to indirect land-use change (ILUC) and the associated release of carbon stocks (Searchinger et al. 2008; McCarl 2008). This leakage effect is worrisome for tropical forests, which are falling under expansions of land use for settlement, forestry and agriculture as driven by multiple factors (Geist and Lambin 2002). Regulators have therefore broadened the scope of LCA, expanding its boundaries both spatially and temporally (CARB 2009; EPA 2010). Such consequential LCA incorporates aggregate estimates of global commodity market interactions. Applied in regulation, it entails assumptions about discounting and how long it takes to pay back the "carbon debt" associated with land-use change (Fargione et al. 2008; Gibbs et al. 2008).

This more expansive form of LCA entails not only difficult to verify (and often unverified) assumptions about numerous critical aspects of GHG emissions associated with feedstock and fuel production, but also inherently unverifiable assumptions about future impacts pertaining to land-use effects and carbon uptake. Nevertheless, such methods underpin the use of biofuels for compliance with carbon-related fuel policies including California's Low-Carbon Fuel Standard (LCFS; CARB 2009) and the U.S. Federal Renewable Fuel Standard (RFS; EPA 2010).

These issues highlight the limitations of conventional energy policy thinking regarding renewable versus fossil fuels. The biofuels conundrum can be seen as part of the broader

challenge of jointly managing the carbon dioxide (CO₂), nitrous oxide (N₂O) and other GHG impacts from stocks and flows in coupled energy and land-use systems globally (Wise et al. 2009; Melillo et al. 2009). From the perspective of resource economics, it is not obvious that LCA is the right tool for regulation. A policy analytic justification for regulatory application of LCA is strikingly absent from the literature, although criticisms are starting to appear (Holland et al. 2009). Proponents simply have asserted that policy should be based on LCA (e.g., DeCicco & Lynd 1997; Sperling & Yeh 2009), apparently assuming that its utility as a technology assessment tool implies its value as a regulatory tool.

Upon reflection, policy is best defined using current-period accounting of carbon stocks and flows, ideally with direct, measurement-based, verifiable tallies of GHG emissions from the production and use of all fuels and feedstocks. Reflecting the rubric, "what gets measured, gets managed," it would motivate all entities in fuel supply chains to minimize the emissions under their control, i.e., within the scope of their operations, but avoid regulating entities for impacts beyond their control. The policy should also mitigate any remaining emissions, such as leakages caused by market-induced ILUC that no particular entity controls. In short, it would establish a carbon management paradigm that provides incentives to minimize emissions from both fuel production and fuel consumption regardless of what the fuel is called. Although fully establishing this ideal will not be possible initially, climate protection is best served by putting its elements in place from the inception of national policy regime rather than using approaches such as LCA that are poorly grounded in the principles of sound environmental management.

ANNUAL BASIS CARBON ACCOUNTING

Effective carbon management must ultimately rely on in situ measurement of stocks and flows on a regular basis with what can be termed annual basis carbon ("ABC") accounting. Here "carbon" refers to all GHGs of concern and "annual" means yearly or other relatively short period, e.g., five years for tracking changes in carbon stocks and analyzing data over multiple growing seasons. Such a system would be "count as you go," without society assuming risks of carbon debt based on judgments about discount rates and acceptable payback times.

ABC accounting underpins cap-and-trade policy as defined to date for fossil CO₂ emissions. Applying it is straightforward for stationary sources, such as power plants and industrial

facilities, and for end-use CO₂ from transportation fuels, where simple chemistry enables accurate measurement through points of fuel distribution in lieu of vehicle tailpipes. Emissions inventories are then tied to real sources rather than the LCA abstraction of "carbon footprint," clarifying questions of which entities reasonably can be held accountable for what emissions.

ABC accounting with appropriate reporting periods can also apply for managing carbon stocks and sinks (Reilly & Asadoorian 2007). Although these issues are treated by more complex methods under the Kyoto Protocol, the result has been erroneous carbon accounting for bioenergy (Searchinger et al. 2009) and other inconsistencies (Reilly et al. 2007). The need to rethink climate policy for biofuels relates directly to the need to rethink it more broadly with respect to the treatment of land use. Although measuring terrestrial impacts is difficult, attempting to handle these issues through LCA rather than ABC accounting does not avoid the difficulties, but can confuse matters with debates about what and how to model.

Traditional methods of energy policy analysis, including fuels LCA, neglect the linkage of energy systems, both fossil and renewable, to land, with its implications for the global carbon cycle and, more broadly, to nitrogen, water and other terrestrial cycles affecting climate (Delucchi 2010). Nevertheless, these incomplete methods have shaped public thinking and policymaking to date. A key defect is the automatic crediting of biogenic carbon, that is, the assumption that biofuel use directly emits no net CO₂ because its molecular carbon was recently absorbed from the atmosphere. That convention looks narrowly at energy-related fluxes while neglecting carbon stocks.

By assuming automatic crediting, GHG emissions caps as proposed to date cover only the fossil-based carbon in fuels. Although some production-phase biofuel emissions are covered, such as those from fossil fuels and fossil-derived inputs used by farms and biorefineries, failing to cover use-phase biogenic CO₂ creates an incentive for biofuels regardless of their actual GHG impacts. Automatic crediting is also used in lifecycle-based regulation as applied in California's LCFS and the expanded RFS (CARB 2009; EPA 2010). Having omitted biogenic CO₂ emissions from end-use consumption, these LCA-based policies attempt to account for production and indirect emissions through an expansive regulatory reach, asserting that all emissions can be addressed through the single but highly artificial metric of fuel carbon intensity (e.g., gCO₂eq/MJ).

While technically correct in LCA, automatic crediting of biogenic carbon obscures responsibility for the physical sources of emissions in the fuel's lifecycle. The result is a misplaced burden of proof. Fuel product suppliers and consumers are relieved of responsibility for the definite, direct CO₂ emissions at end-use. However, the responsibility for the substantial emissions (direct and indirect, CO₂ as well as N₂O and other impacts) associated with the credited carbon uptake is passed off through a long, convoluted, dynamic and currently untraceable supply chain for feedstocks and other inputs. Arguments then ensue about who is responsible for what portions of emissions and how to expand LCA system boundaries (spatially and temporally) to adequately account for all impacts. The debate has become particularly fraught for ILUC, which greatly influences estimates of GHG intensity. Not surprisingly, expansive LCA-based regulations have met strong opposition from the affected industries (Geman 2009; Guerrero 2010).

ELEMENTS OF A FUELS CARBON MANAGEMENT POLICY

A policy based on ABC accounting for managing the GHG emissions associated with biofuels is described by DeCicco (2009), which also illustrates the application of the approach outlined here with a quantitative example drawn from a detailed case study of a U.S. ethanol facility.

A foundation of sound policy is treating all CO₂ emissions that occur in the transportation sector at face value, i.e., as directly measurable emissions to the atmosphere, without automatic crediting of biogenic carbon. Doing so requires the right point of regulation (POR) for allowance submission. Because transportation fuels supplied to end users can contain components (such as ethanol as well as other bio- or fossil-derived fuel formulation compounds) blended in at distribution terminals, the POR should be the point of finished fuel distribution. If all fuel carbon (biogenic and fossil) is thereby tracked, biofuel suppliers will see essentially the same market value for their product under a carbon cap as they see without a cap in place. They are not competitively disadvantaged by such a policy but neither do they see the unconditional increase in value for biofuels that occurs with automatic crediting.

Abandoning an automatic credit for biogenic carbon may seem disconcerting to some analysts, but it is the only way to define a consistent GHG accounting framework without resorting to unverifiable assumptions about the extent of net carbon uptake that complicate other approaches to policy. It is not tantamount to putting part of the agricultural sector under a carbon cap.

Rather, it is a more accurate specification of how a cap should apply to the transportation sector. After all, the CO₂ from vehicle tailpipes is an "emissions certain" (a well-defined quantity of molecular CO₂ entering the atmosphere) regardless of the source of the carbon in the fuel.

The second part of a policy is a protocol to track carbon uptake and uncapped GHG emissions in biofuel and feedstock supply chains. Such a mechanism will enable producers to obtain a verifiable credit for net carbon uptake in biofuel or fuel feedstock products. The protocol would involve reporting GHG balances at the facility level, meaning farms, managed forests, biorefineries or other processing plants. The system boundary for any such facility is well-defined and GHG emissions are in principle measurable, although doing so is challenging for some important fluxes such as soil carbon and N₂O. Measuring the biogenic carbon in a feedstock is straightforward and could be reported as a carbon uptake credit from which facility-level GHG emissions are debited unless already covered by allowances submitted elsewhere under the cap (e.g., for purchased electricity).

Barring direct GHG regulation of agriculture (which has not been seriously proposed), cap-and-trade will affect the sector indirectly through carbon price impacts on fossil-based inputs and the potential for income opportunities from offsets (Adams 2009). Consistent with agriculture and forestry being uncapped, net carbon uptake tracking would be voluntary. But with CO₂ uptake no longer automatically credited in the capped transportation fuels sector, the burden of proof shifts to feedstock producers. Although producers would have an incentive to document net uptake, they would not have a reporting obligation. CO₂ uptake and uncapped emissions tracking would be required only if a producer wishes to realize credit in the carbon-constrained fuels end-use market. Although it is not a perfect policy in the sense of directly regulating all fuel-related emissions, this approach does avoid the egregious problems due to automatic crediting.

Defining the net uptake crediting protocol at the facility level will reveal -- and enable policy to exploit -- real-world variability. This is in contrast to the process-based approach of LCA regulations. For example, the RFS (EPA 2010) treats all corn the same, avoiding any look at the variability in, say, N₂O emissions for different locations, growing conditions, fertilizing practices, and so on. LCA-based regulations also treat biorefining according to generic process characteristics, using a "check box" approach that ignores the variability in emissions for a given process at different sites, which can vary temporally based on market conditions, changes in

inputs and changes in product mix. In contrast, an uptake crediting protocol based on voluntary facility-level reporting will foster scientific GHG management, which involves revealing observable variability to spur learning and enable selection for best practices.

EPA's reason for avoiding differentiation of given feedstocks is that they are fungible commodities. However, this need not be a barrier; indeed, developing a way to track emissions impacts through supply chains will be essential for rational GHG management of liquid fuels, which are likely to remain fungible commodities regardless of the source. Data on net carbon uptake could be incorporated into commodity trading contracts, as has been proposed to handle broader sustainability criteria for biofuels (Mathews 2008).

The final part of a policy is a mechanism for addressing leakage, specifically emissions from ILUC. Although estimates vary, ILUC is large enough to greatly influence the net GHG impact of biofuels (Melillo et al. 2009). It is mediated by price signals tied to demand for agricultural and forestry products. If the biofuel-related portion of this price signal were neutralized, or an equal-and-opposite signal created for protecting forests, then that would be a way to mitigate emissions from ILUC.

This could be accomplished by establishing a Land Protection Fund (LPF) for purchasing international forest carbon offsets in proportion to the ILUC emissions estimated to occur as a consequence of biofuel production. The LPF would be administered at the national level, commensurate with the scale and type of a nation's biofuel use, and designed to leverage programs for Reducing Emissions from Deforestation and Forest Degradation (REDD) being developed internationally (Gibbs et al. 2007). REDD is based on the body of work that emphasizes the importance of financial incentives for protecting forests (Gullison et al. 2007; Mollicone et al. 2007).

The LPF should not come at the expense of other REDD funding. To the extent that biofuel production indirectly exacerbates deforestation, funds for REDD should be increased beyond what is otherwise deemed appropriate. A number of options can be explored for financing the LPF, a question meriting careful discussion that is left for future work. The requisite mitigation levels can be estimated using same models now applied to incorporate ILUC into regulations. Applying these methods to determine ILUC mitigation needs at a national scale is arguably a

more appropriate use of such highly aggregate global models than reducing their results to product-specific values for LCA-based regulations such as an LCFS or RFS.

MANAGING EMISSIONS INSTEAD OF DISPUTING FUELS

A perhaps surprising aspect of the approach outlined here is that it does not entail explicit comparison of fuels. With all molecular carbon treated equally as a source of CO₂ emissions certain during fuel use, attention turns to handling production phase ("upstream") emissions by tracking carbon uptake and uncapped emissions in the supply chain (in addition to cap coverage of major stationary sources). The focus is on production facilities where emissions actually occur rather than on products to which emissions are imputed through LCA. Moreover, because liquid fuels and their feedstocks are fungible commodities, it is unclear that differentiating them with a product-based metric is as effective as pricing their production-related emissions, which this approach achieves by exposing fuel supply chains to the carbon market.

From a deeper perspective, attempting to regulate fuels through LCA can be seen as premised on a "fallacy of misplaced concreteness" (Whitehead 1927). A form of logical reification, this fallacy refers to treating an abstract construct (in this case, a fuel's lifecycle GHG emissions) as if it were a concrete physical property (such as a fuel's chemical composition). Seen in this light, LCA-based regulation is a unproven and radical departure from traditional environmental policy based on measured substances or impacts of concern. For biofuels, the key impacts occur at fields and facilities; those locations are the sources of physical emissions that must be measured to ensure transparency. Carbon intensity is purely notional; it cannot be measured in a repeatable way as can, for example, limits on sulfur or other chemical specifications for fuels. Although ILUC brings the issue to a head, the uncertainty and variability of many other production-related emissions are also problematic. The high degree of abstraction entailed in lifecycle GHG estimates is clear in the CARB (2009) and EPA (2010) documents, which reveal how regulatory compliance heavily depends on numerous modeling assumptions, some of which (such as those for amortizing carbon debt) are inherently not empirical.

In contrast, a GHG management policy using current-period, facilities-based ABC accounting does not require making assumptions about emissions reductions based on abstract estimates of complex systems and their spatial and temporal behavior. Neither does it require resolving long-

running debates about the climate benefits of biofuels. Rather, it acknowledges the reality of biofuels in the marketplace and the fact that neither fossil fuel supply systems nor agricultural systems have been carbon constrained to date. A cap-based policy using ABC accounting can co-exist with the RFS or other biofuel mandates while avoiding the need for GHG lifecycle requirements in the RFS or an LCFS. As a rational system for carbon management, it would create incentives for lower-net-carbon options regardless of their form and whatever their emissions may be today, recognizing that some of the most cost-effective reduction opportunities might well be found through scientific management of existing GHG-intensive systems.

While climate protection may have been a rationale for promoting biofuels, an unvarnished political analysis shows that support for biofuels rests on their value for rural economic development -- an important interest in most political systems -- amplified by concerns about energy security. Although many environmentalists promoted biofuels, climate concerns are not a foundation for biofuels policy. For example, legislation that expanded the RFS passed the U.S. Senate with a vote of 86-8 (Sissine 2007), clearly supported by many members as yet opposed to climate policy *per se*.

The voluntary approach outlined here will probably only motivate reporting by producers whose carbon uptake net of uncapped emissions is high enough to make it worthwhile to opt into the system. Nevertheless, it will foster the beginning of measurement-based GHG management in biofuel and feedstock production. Such a policy would harness approaches like those already used to enhance agricultural productivity by engaging producers, related businesses, extension services and agricultural researchers in a search for low-GHG solutions. A net carbon uptake crediting system coupled to a cap will create a market pull for emerging technologies such as cellulosic processing while providing a market incentive to further improve the "carbon efficiency" of mature technologies that exist at scale today.

Although this paper focuses on biofuels, similar considerations apply to bioenergy in general. Note also that the direct uptake crediting protocol is not the same as treating biofuels as a carbon offset. Although it can draw on the measurement and verification techniques developed for agricultural offsets accounting, the protocol outlined here yields a direct, annual measure of net carbon uptake, rather than an emissions reduction relative to some baseline, and so avoids the need for tests of additionality and permanence.

CONCLUSION

While further analysis and development are needed for the approach outlined here, its paradigm of applying ABC accounting tied to a carbon cap offers a tractable climate policy not just for biofuels, but for transportation fuels generally. Cap-and-trade creates a price signal that fosters economic efficiency and, given adequate integrity and transparency, enables an extension of carbon management to uncapped sectors and sources. A cap-based ABC accounting framework provides mechanisms for handling challenges of policy diffusion and problems of leakage due to the impossibility of imposing caps everywhere at once. It is therefore well suited for addressing biofuels, which involve uncapped sectors (agriculture and forestry) and indirect impacts in uncapped jurisdictions across international borders.

In short, including transportation fuels in the cap would put the majority of the sector's emissions under carbon management. Biofuels present a special problem because biogenic carbon is excluded from fossil-based caps as proposed to date and their production is intrinsically coupled to terrestrial carbon stocks. These issues can be handled through an approach that accounts for all fuel end-use CO₂ emissions at a well-specified point of regulation; a protocol to track carbon uptake and uncapped emissions in fuel and feedstock supply chains; and a land protection fund to mitigate ILUC. Such an approach will create a more complete carbon management framework for the sector and in so doing, move policy closer to the integrated treatment of fossil energy and terrestrial GHG sources ultimately needed for effective climate protection. ■

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