Corn Ethanol Saves the Climate:
The only question is by how much

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All the bad news about ethanol has been definitively disproven by data. It is time to understand the vast lost carbon savings suffered by the planet due to the continuing use of petrol rather than ethanol.

Understanding Ethanol's Carbon Intensity

The most sensitive assessment of the climate impacts of biofuels is **consequential life cycle analysis**, a highly detailed approach looking at a specific biofuel's (and some would argue a specific quantity of that biofuel produced over a defined period of time) impact on a status quo situation in food, fuel, transportation, labor and other sectors. As such, consequential life cycle analysis is ill-suited to regulations, which require simplicity.

Another type of life cycle analysis is **attributional life cycle analysis**, which compares a biofuel to its components without asking how those components will change because of biofuels. In other words, in an attributional life cycle calculation, it is assumed that the sugarcane cultivation inputs for ethanol production are the same as sugarcane used for sugar, or that the oil displaced by ethanol is oil with average GHG emissions rather than calculating the GHG emissions of the marginal oil that would be displaced. For example, all biofuel regulatory policies use a static fossil fuel comparator as a benchmark to measure biofuels against; this fossil fuel comparator is an attributional tool.

All major biofuel regulatory frameworks aspire to apply a robust life cycle approach to calculating biofuel or bioenergy GHG outcomes. Each regulatory framework considers cultivation, transportation, processing, etc. emissions, and thus the oft made historical criticism of biofuel policies that they do not attempt to consider all emissions is no longer true. However, each biofuel regulatory framework employs its own combination of attributional and consequential approaches, with the result that there is no common international understanding of how to assess biofuels and their GHG mitigation impacts.

Accordingly, it is unclear how climate policymakers can reconcile robust local experience in biofuels regulation with efforts to realize the potential of biofuels to generate global climate benefits. This paper attempts to bridge this gap in a way that assures policymakers that a simplified assessment methodology is available that is consistent with national methodologies and that has a high degree of workability and reliability.

This effort is aided by contextualizing the empirical evidence available now from the first decade of ethanol being rolled out at scale as a climate mitigation tool. While ethanol certainly existed as a fuel for a century prior to the last decade, it is only in the last decade that its GHG impacts have been studied in earnest with any rigor.

Margins of Error

The figures presented in this paper can be debated on methodological grounds, but they are in the right ballpark and are "down the middle" estimates rather than reflecting any extreme positions. They are backed up by trend lines and reflect the most robust empirical evidence, instead of being the result of models that use pre-2005 data and assumptions (which were the only real tools available a decade ago). Currently, the largest discrepancies in assessing ethanol GHG impacts come not from the real world but, rather, from disparities between the projections of old models and actual empirical evidence. Unfortunately and surprisingly, stakeholders often argue that old models deserve priority over real world data.

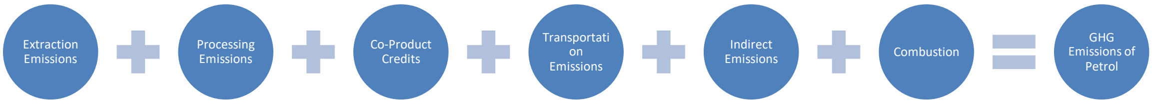
<u>Methodology</u>

From a climate perspective the fundamental question is: **is ethanol better than petrol?**

To answer this question, the lifecycle GHG emissions of ethanol must be compared to the lifecycle GHG emissions of petrol.

The lifecycle emissions of ethanol represent the aggregate of the production chain emissions shown below:

Correspondingly, the lifecycle emissions of petrol represent the aggregate of the production chain emissions shown below:



The common metric for all of these steps is grams of CO2 equivalent per megajoule. For the sake of simplicity, we just use grams throughout this paper.

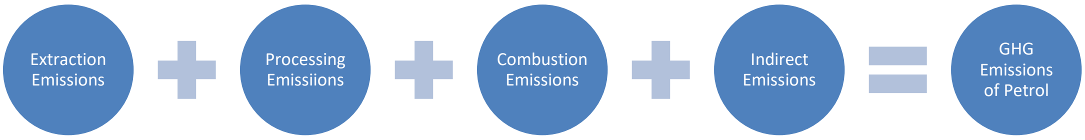
As can be seen above, the analysis is similar for both commodities. Indeed, as the purpose of biofuels is to displace oil, biofuels must always be examined in parallel with an examination of the oil displaced. Unfortunately, this basic truth is often forgotten.

The way data is collected, oil co-products can be removed from the formula above without changing any results, and transport can be removed from both formulae for the simple reason that these emission values are small (always for biofuels and usually for fossil fuels).

Biofuel emission calculations usually credit the biofuel for carbon that will be removed from the atmosphere in the growing season after the biofuel feedstock is harvested (or for the carbon that was removed by the feedstock). Often this credit is expressed by ignoring biofuel combustion emissions as a proxy for assigning a credit for the crop in question being a carbon sink. A minority of commentators argue that this credit should not exist because the feedstock would grow anyway, but that argument doesn’t hold. With additional ethanol demand we produce more feedstock to supply that demand or other sectors consume less of this feedstock, or both. If feedstock was to grow anyway, then no ILUC concept could exist and no cultivation emissions would be relevant either. In this paper, we assume the credit to be appropriate and so ignore the combustion emissions of ethanol.

With these simplifications the question becomes whether these emissions:

are greater or less than these emissions:



It should be noted that the ethanol emissions framework above applies just as well to wheat ethanol as to cellulosic ethanol and so its logic is universal. For example, for ethanol produced from waste industrial gases, there would be no emissions other that ethanol production emissions, so long as the gas feedstock was waste. For algae based ethanol, there would be no indirect emissions (although as algae becomes commercialized nutrient impacts may call for some account of indirect impacts). For cellulosic ethanol from straw, both cultivation emissions and indirect emissions are relevant, although both are small.

Accordingly, for global policymakers, there are really only eight categories of emissions that are of primary interest, and these are each discussed below:

1. <u>Feedstock Cultivation</u>: Cultivation emissions are, under most biofuel policies, increasingly calculated on an **actual basis** rather than a **default or typical basis**. On an actual approach, data is collected from farmers (bottom-up approach), while on a default approach, some regulatory body has calculated cultivation emissions as a static number (top-down approach). While actual calculation is more accurate and has the great benefit of allowing biofuel producers to identify more climate friendly feedstock, default approaches are often impracticable in long supply chains. It should be noted that if a forest is cut down to produce feedstock for a specific ethanol production supply chain (which is **direct land use change**), then the resulting emissions would be included here, which is a theoretical rather than a practical issue since it is inapplicable to at least 99% of all global ethanol production. Most ethanol producers, however, have short supply chains. Over the past decade, biofuel policies have proven to result in **sustainable intensification** along their supply chains (e.g. higher yields per hectare, less waste and lower per unit applications of pesticides and herbicides as well as fertilisers), meaning that feedstock cultivation emissions have been (slightly) declining over the past decade.

2. <u>Ethanol Production</u>: Ethanol production processes today are simply incomparable to those of a decade ago. Per unit energy use has plummeted by almost 50%, and yields per ton of feedstock have improved dramatically. A 2005 vintage ethanol plant in Europe or the United States would, quite simply, almost immediately go bankrupt today. Any plant that existed in 2005 and is operating today has, by definition,

undergone large process improvements over the past decade. As a result, process emissions in ethanol are declining every year.

3. Ethanol Co-Products: A decade ago, many grain ethanol co-products were either discarded or were so poorly processed that they had only a small market value. There are today many different co-products and much more valuable co-products, and in the average corn ethanol plant nothing is discarded. As a result of these changes, the co-product credit for ethanol facilities is increasing and will continue to increase. Whether these co-products are credited based on their energy content (which is a simple approach and the one used in existing models) or on the GHG emissions impact of the materials they displace (which is more accurate but less clear cut given the diversity of products across ethanol plants) is an important issue. This choice however does not alter the fact that co-product credits have been increasing.

4. Ethanol Indirect Impacts: The most discussed (although not the only nor potentially the most important) indirect impact of ethanol is **indirect land use change** or **iLUC**, which is the imputed change in global land use resulting from increased demand for sugarcane, sugarbeet, wheat and corn. In other words, if feedstock used for ethanol production diminishes supply of that feedstock for feed markets, then a static demand will mean increased prices for the remaining amount of the feedstock, leading to some amount of conversion of land to agriculture. Any such conversion could have climate impacts, and if the land converted has a high carbon stock (such as a forest or a peat bog), then there could be a large climate impact. Other indirect impacts of ethanol could be positive (e.g. reducing oil's market share would reduce the oil price, making fertilizer less expensive and so increasing food supply), but there has been no comprehensive effort to examine indirect impacts of ethanol. Almost the sole focus has been on iLUC. With respect to iLUC, early calculations in the last decade suggested very high emissions. However, since then three trends have changed the nature of iLUC in ethanol policy analyses. First, not all ethanol feedstock has the fundamental displacement impact required for there to be ILUC (e.g. if feedstock is grown as part of a crop rotation that would otherwise be fallow, or if there is double cropping, or above trend line yield increases, etc.). Second, feedstock price increases in corn, wheat and sugar have fallen so short of modelled expectations (indeed, in most cases, prices in real terms are now lower than a decade ago) that the price increases that are a necessary precondition for iLUC in the original models do not exist. Third, new calculations of iLUC using models yield ever lower estimates of iLUC. The most recent models suggest a 10 g "iLUC factor" for ethanol as opposed to estimates of an order of magnitude larger only five years ago. Even though the trend in iLUC factor quantification is strongly downward, we nevertheless use a 15 g factor for ethanol in this paper given the political sensitivity of iLUC.

5. Oil Extraction: In contrast to the picture for ethanol, oil extraction emissions have been increasing over time and are expected to continue to increase. With low oil prices, the "worst" oil may be left in the ground temporarily, but extraction emissions will nevertheless continue to increase over the long term. Countervailing this trend, restrictions on flaring reduce oil extraction emissions slightly.

6. Refining Efficiency: As petrol refining is a mature technology, there are no technological breakthroughs that are expected to lower refining emissions going forward. Currently, the mothballing of old refineries and so the increasing market share

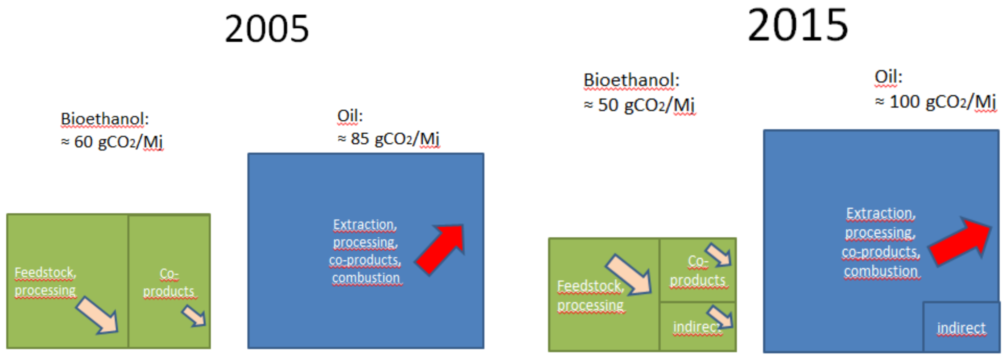
of new refineries is temporarily manifesting itself as an improvement in refining GHG emissions.

7. Oil Indirect Impacts: The indirect impacts of oil include wars, pollution from spills (which ethanol escapes since it degrades so quickly), inequality, etc. Only a few studies on the GHG impacts of these phenomena exist and, ironically, proponents of including ethanol indirect impacts in lifecycle analyses do not argue for the same treatment of oil. We believe, drawing on some academic work in this area, that a debit of 5 g is a good quantification of oil's indirect impacts. We note that as we have added 5 g to our estimate of iLUC, by the same logic here we would be arguing that oil has no indirect impacts but because oil is disfavoured, we are rounding up to 5 g/MJ. Again, it is critical to treat biofuels and oil in a parallel manner.
8. Petrol Combustion: Petrol combustion emissions are slightly improving over time as more efficient engines penetrate the market. Moreover, petrol with low amounts of ethanol (up to 30% by volume) also improves the combustion efficiency of petrol. As we have excluded ethanol emissions, both of these improvements over time would act to make petrol (misleadingly) appear to make up some ground against ethanol. But, for the next five years, this issue will not have a material impact.

To put these categories into perspective, the reasons why the same corn ethanol that in the US exhibits "only 20%" GHG savings, but exhibits 50% GHG savings in Europe are because (i) the US applies an attributional iLUC factor while the EU has no ILUC factor, and (ii) the US methodology does not even credit co-products with their energy value. Under the methodology presented here, this same corn ethanol would have total emissions of around 55 grams, or something near 40% GHG savings in both the US and European methodologies.

Ten years ago the total GHG emissions of ethanol were only somewhat better than fossil fuel (cca. 60 v. 85 g). The gap has widened since; in a decade, GHG emissions of ethanol have decreased to about 50 grams on average, while fossil fuel has become dirtier (thanks to unconventional oil). Both trends are expected to continue, resulting in an ever widening difference in climate profile.

Average GHG emissions of ethanol (including ILUC) and oil in 2005 and today



Climate is, of course, important, but even for climate policymakers, it is not the only consideration. Biofuels have been criticised for damaging food security, land grabbing and biodiversity. Therefore the picture presented needs to be accompanied by those assessments. Luckily, the past couple of years have shown that, although plausible, dire predictions about food security have not come true – the impacts of ethanol on global food security have been marginal. Land grabbing is also a valid concern, but again, it has been marginal – at worst 1% of ethanol produced globally may be associated with some kind of land grabbing. Lastly, trying to link ethanol to biodiversity loss is extremely difficult. So, while these three problems are all important, and while none should be ignored as part of a robust global biofuel consensus, in each case the impacts are so small that using them to argue against ethanol use in general is disingenuous.

Simplified Methodology

With this discussion in mind, the following methodology can be used to assess ethanol in global climate negotiations.

Or, rather, that if the feedstock and processing emissions of ethanol minus a credit for the (energy value- so as the be conservative) of the co-products is less than 95 grams, then that ethanol is likely better for the climate than petrol over the duration of the policy period. Given sensitivities about ethanol, however, a 95 gram threshold is likely to generate as much criticism as support.

Any ethanol that can today achieve 75 grams under this approach is almost certain to be better than petrol throughout the policy period. Accordingly, not supporting such ethanol would be antithetical to policy goals.

All corn ethanol easily meets this standard. Some even goes as low as 10 grams.